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Measuring and factors affecting the risk attitudes of selected farmers in Story County, Iowa

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CHAPTER I. INTRODUCTION

Iowa farmers are like other farmers in the United States or elsewhere in the world; they face continuous risky situations in their farming operations and decisions.

Risk Attitudes

How Iowa farmers make decisions under risky situations is of paramount importance not only to farmers themselves but also to all others concerned. How they decide the resulting behavior depends upon how they assign the seriousness or probability to a risky situation and how they personally feel (like or dislike) about the risky situations. Some of them do not want any risk, while some may enjoy the risk and others may care only slightly about risk. Most of them are likely to lie between the one who does not want risk at all and the one who cares little about risk. The degree to which farmers like or dislike risk is to be called "the risk attitude" in this study.

Kinds of Uncertainty

There are four kinds of risk or uncertainty arising from the farming business [11, 35]. First, the price uncertainty; farmers do not generally know the price of a product they will sell in the future. They have to wait one season for the seasonal crops, a year for the annual crop, years for the cattle, and for many years for fruit trees. The distant future prices are very uncertain to farmers who have no control over prices. Second, natures uncertainties; farmers are at the mercy of nature. A successful agricultural production needs favorable natural conditions; this can not easily be predicted correctly or controlled. Many well-to-do farmers are reduced to poverty following successive unfavorable natural conditions. Third is the institutional uncertainty; the institutional change can directly or indirectly affect farmers. For example, changes in U.S. grain exporting to the U.S.S.R. may cause many changes in domestic grain prices which directly effect net farm income of the farmers. Last, the technological uncertainty, the fact that agriculture is dynamic, continuous new technology in the form of seeds, insecticides, machinery, etc. The consequences of these new inputs lead to great uncertainty for the farmer. For instance, machinery may become obsolete or high yield variety seeds may be vulnerable to disease.

The Problems

With all of the previously mentioned uncertain situations that farmers face, farmers have to make correct decisions and successfully decide what to do and how to cope with management problems. How Iowa farmers make decisions and manage risky situations is not definitely known. It is important for the public, government decision-makers, and Iowa farmers themselves, to be informed about the response and behavior in such risky situations. One way to help understand how Iowa farmers behave when faced with uncertainty, is to know quantitatively their risk attitude.

The risk attitude is very abstract. It is only a feeling of an individual farmer which is not measurable in material units. However, science needs measurement, and science without measurement can hardly (or not at all) be useful. Therefore, a serious attempt must be made to measure this risk attitude.

A better understanding of the Iowa farmer is possible when there is further investigation of what factors affect their risk attitudes. An attempt, therefore, should be made to find out how much each factor affects the attitude.

There can be many factors responsible for the risk attitude among Iowa farmers. Some of these are, education background, size of farm and size of his assets, age of the farmer, size of family, etc.

In brief, the main focus of this study will center around the measurement of risk attitudes of farmers in Story County, Iowa and an investigation of what and how many factors affect these attitudes.

Objectives of the Study

The main objective of this study is to investigate the stated problems and find solutions for them. Therefore, these main objectives may be listed:

(1) To measure the risk attitude of selected farmers in Story County, Iowa;

(2) To identify socio-economic factors that affect the risk attitudes of the selected farmers;

(3) And, also, an attempt to measure the degree of effect of socio-economic factors upon risk attitudes.

These three objectives can not be reached without passing through the steps of research procedures. By doing so, it creates other secondary objectives of the study. They will be represented as follows:

(1) There is no published information on risk attitudes of the farmer; this suggests that the primary data must be obtained. This state suggests that

the needed objective is to select farmers for sampling, construct questionnaires for these selected farmers, and conduct field investigation, using these selected farmers.

(2) An investigation into the theoretical framework of this study is then possible. One way is to use the utility functions. Therefore, another objective is to outline the theoretical framework of the utility function and to show how the utility function may lead to the estimation of the risk attitude.

(3) A deep consideration of what factors affect the risk attitude can be undertaken.

(4) Besides the data from (1) and the theoretical framework from (2), it is necessary to identify the analytical procedures and methods which are most appropriate. Thus, the last objective is to select and describe the analytical method. An explanation of utility function estimation and the statistical ordinary least square (OLS) method, is felt necessary.

In brief, the objectives of this study are to study the risk attitudes of Iowa farmers, identify the factors affecting these attitudes, and any other related or desired objectives of this research.

CHAPTER II. REVIEW OF LITERATURE

An economic study of risk attitudes and the resulting human behavior when faced with risky situations, has been recognized relatively recently. We will divide the approach into four categories; i.e., direct application of the utility function, observation of how farmers manage input demand, the experimental method, and mathematical risk programming.

Direct Application of the Utility Function

This kind of utility function defining the ordinal utility of a farmer, is a function of the income or wealth or both, $U = U(Y)$, where U is the ordinal utility and Y is the income which is the argument of the function. From this function, there are generally five measurable concepts of the risk attitude. They are: (1) the second derivative of the utility function of $U''(Y)$, (2) the negative of the second derivative of the utility function divided by the first derivative of the utility function or $-U''(Y)/U'(Y)$, (3) the derivative of the expected income with respect to the variance of the income or $\partial EY/\partial\delta^2$, (4) the $\partial EY/\partial\delta^2$, with expected utility or EU constant, and (5) the risk premium, π.

The decision-makers are classified as the risk averse, the risk neutral, and the risk preference. These classifications are based on the above five measurable concepts.

The risk averse farmer has the following characteristics,

(1) $U''(Y) < 0$

(2) $\partial EU/\partial\delta^2 < 0$

(3) $-U''(Y)/U'(Y) > 0$

(4) $\partial EY/\partial\delta^2$ with EU constant > 0

and

(5) $\pi > 0$

The risk preference farmer has the inequality signs reversed from the risk averse farmer. The risk neutral farmer has the equality signs instead of the inequality signs.

The expression of $U''(Y) < 0$ simply based on the general economic assumption that the marginal utility of money is diminishing.

The measuring concept of $-U''(Y)/U'(Y)$ was contributed by Pratt [58]. This concept developed from the fact that the utility function is the ordinal concept which has the characteristics of the monotonic transformation. The new concept of Pratt provides the unique measurement of these transformable functions. He called this concept the absolute risk measurement, and he developed another concept of the risk measurement which is defined as $[-U''(Y)/U'(Y)]Y$, which he called the relative risk measurement.

The method of the measurement of $\partial EY/\partial \delta^2$ with EU constant is contributed by Magnusson [45]. This tells the substitution between the expected income and the risk with keeping the expected utility constant. The keeping EU constant is the significant importance of this method. If not so, the actual or real substitution effect between EY and $\partial \delta^2$ cannot be found because the change of EY or the change of δ^2 will automatically lead to the change of EU too.

The expression of $\pi > 0$ means that the risk averse farmer is willing to pay the maximum amount of π in order to avoid the risky situations.

The examples of this method of the study are the works done by Dillon and Scandizzo [16], Francisco and Anderson [22], Halter and Mason [29], Lin et al. [44], and Officer and Halter [56], Benito [8], Masson [51] and Roumasset [59].

The direct application of the utility function is characterized by using the primary data obtained through the interview technique. This gives higher doubt about the validity of this type of study.

The use of the utility function plus the interview technique is being attacked by the following arguments.

(1) Biased by the interview technique. For example, if the interviewers are risk averse, they may use the language indirectly to convince the farmers to agree with them. This leads Binswanger [9] to develop the experimental method.

(2) Hypothetical risky situations given to the farmers may not be a good representation of the real situation, i.e., the answer the farmer gives may not be his choice in an actual farming business decision.

(3) The hypothetical risky situations themselves represent a gambling characteristic. The farmers may have personal values against gambling which would lead them to select the hypothetical risky situations with the risk averse expression. But, in reality, the farmer does not feel that the farming business is a gamble and he may prefer risk preference.

(4) When farmers make decisions in actual situations, they may not rely on monetary considerations alone. Therefore, the risk attitude derived from the utility function as a function of money alone

may not work in reality.

(5) The selected form of the utility function may lead to inappropriate implications and conclusions as pointed out by Lin and Chang [43].

(6) Farmers answering the questionnaire do not have to take the consequences for decisions based upon the hypothetical situations of the questionnaire. Also, they do not have much time to make their decisions. In reality, their actual decisions may be based upon discussion with family members and allow the farmer more time to weigh his decisions. This also led Binswanger [9] to develop the experimental method.

In a comparative study of many methods by Lin et al. [43], they concluded that this direct application of the utility function was the poorest method for predicting farmers behavior when dealing with actual risky farm situations.

This study selected this method of study because there is no evidence showing which method is the best one or that any method is superior to the others. There is more discussion about this method and the theory related in the following two chapters.

The Experimental Method

So far, there has only been one study in this category, this was done by Binswanger [9]. He developed this method in order to improve the interview technique with the use of the hypothetical risky situations.

However, social science can use the experimental method with some amount of limitation. In the study by Binswanger, the experiment was limited to only zero gain or no loss to the selected farmers in India. The experiment was based on pure gambling. Therefore, this does not represent the real agricultural risk which does not limit it to zero gain, and farmers do not see their farming businesses as gambling.

It is uncertain whether this method is or is not better than the interview method but it is certain that it requires more research funding. The writer of this study personally does not believe that the experimental method is better than the interview method.

The Observation Method

In general, this method observes the farmers behavior in reference to input demand. The theoretical framework of this method is as follows.

Let $U = U(Y)$ where Y is the net farm income, i.e., $EU = EU(E(Y), \delta^2)$, where δ^2 or $\delta^2 Y$ is a variance of Y.

Let Y be a function of the input N, i.e., $\delta^2 Y$ is also the function of the input N, so,

$$EU = EU(E(Y(N)),\delta^2(N))$$

A farmer maximizes the EU by finding the optimum amount of N that should be used, i.e., the equation is differentiated with respect to N and equated to zero:

$$\frac{dEU}{dN} = \frac{\partial EU}{\partial E(Y)} \cdot \frac{\partial E(Y)}{\partial N} + \frac{\partial EU}{\partial \delta^2} \cdot \frac{\partial \delta^2}{\partial N} = 0$$

$$\frac{\partial E(Y)}{\partial N} + \frac{\frac{\partial EU}{\partial \delta^2}}{\frac{\partial EU}{\partial E(Y)}} \cdot \frac{\partial \delta^2}{\partial N} = 0$$

This $\frac{\partial EU}{\partial \delta^2}/\frac{\partial EU}{\partial E(Y)}$ or $\frac{\partial E(Y)}{\partial \delta^2}$ is the same as $\partial EY/\partial \delta^2$, with EU constant given in the section giving the direct application of the utility function.

The expression of $\partial E(Y)/\partial N$ is nothing more than the expected marginal value product less the expected marginal factor cost.[1] Therefore, the equation above may be

[1]The total net farm income Y equals the total gross income TR less the total cost TC, or,

$$Y = TR - TC$$

putting expectation sign, then,

$$E(Y) = E(TR) - E(TC)$$

Let N be an input, so,

$$\frac{\partial E(Y)}{\partial N} = E(MVP) - E(MFC).$$

rewritten as,

$$E(MVP - MFC) + \frac{\partial E(Y)}{\partial \delta^2} \cdot \frac{\partial \delta^2}{\partial N} = 0$$

This expression may be graphically explained as follows

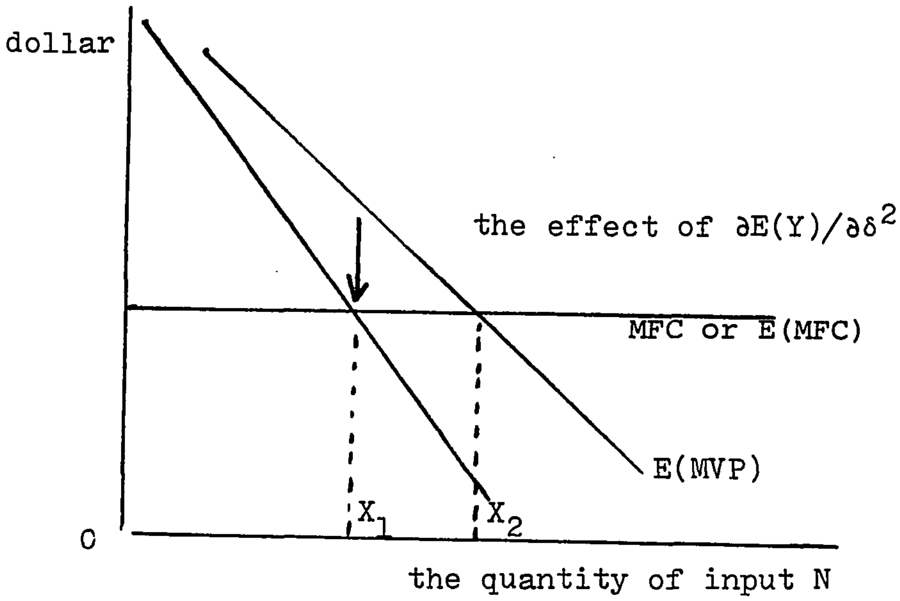

Figure 1. Showing the amount of input used under risk

In the above figure, the risk makes the risk averse farmer use less input, OX_1, than the case without risk, OX_2. The effect of $\partial E(Y)/\partial \delta^2$ is shown in the graph too.

This method involves finding the value of $\partial E(Y)/\partial \delta^2$, given the known values of E(MVP) and $\partial \delta^2/\partial N$. A detailed discussion and example is given by Anderson et al. [1]. A more in-depth theoretical discussion of this method can be found in Magnusson [45].

Based upon this framework, Pope [57] has proposed the econometric approach to estimate the risk attitude coefficients. Moscardi and de Janvry [54] utilized this method within the safety first framework.

This method escapes the criticism of using the utility function, which is constructed from the hypothetical risky situation. However, this method has serious defects also, since it always measures the risk attitude coefficients from the difference between the actual level of input used and the theoretical no risk model (or risk neutral). As a result, it always indicates the risk averse by the farmers. But their difference is not necessarily caused only by the risk aversion of the farmers. In fact, there are many explanations for that difference, such as; farmers may not have sufficient capital to use as much input of EMFC = EMVP, farmers may not maximize net farm income alone, and farmers may not have enough information about EMVP.

The Mathematical Risk Programming Method

This method is a subclassification of the observation method, by looking at the supply side. It sees what the farmers plan to do for their cropping pattern.

The mathematical risk programming uses the risk attitude coefficients in the model. If the risk attitude is rightly specified, the mathematical risk programming should simulate the farm plan which is like the plan made by the farmer.

The following model will illustrate how the risk attitude coefficient is needed for the risk programming model.

As we know, $EU = EU(EY, \delta^2(Y))$

where

Y is the net income, δ^2 or $\delta^2(Y)$ is a variance of Y. The simple function stands for the above EU [see Heifner, 36], i.e.,

$$EU = Y - b\delta^2$$

where b is the parameter. Note that "b" indicates how a farmer views risk; the risk neutral farmer has $b = 0$, the risk averse has $b > 0$ and $b < 0$ for the case of the risk lover.

Taking total differentiation with $dEU = 0$

$$o = dY - bd\delta^2 = 0,$$

i.e., $\frac{d\delta^2}{dY} = \frac{1}{b}$ or $dY/d\delta^2 = b$

Hence, b is nothing more than one kind of coefficient measuring the risk attitude. The problem is to use the risk programming to find out this value of b.

For the example, one type of risk programming which is the quadratic risk programming will be used, i.e., to maximize $Z = cx - bx'vx$, subject to all constraints.

Where c and x are vectors of the net price and the activity level of the farm plan, $x'vx$ is the variance-covariance matrix of the activities. Value b must be given arbitrarily. For each given value of b, there will be the farm plan solution that maximizes the value of Z. Various values of b may be tried for the problem, therefore, various farm plans are simulated. Now, select the farm plan solution which is most like the plan which is actually used by the farmer. The value of b from this selected plan solution is the estimate of the actual b that the farmer actually has in mind.

In practice, the model used for finding the value of the risk attitude coefficients is more complicated. Examples of risk programming are found in Brink and McCarl [12], which used MOTAD linear programming [Hazell, 32] and the work of Hazell and Scandizzo [33] is also a good example.

Other Methods

There are other methods which developed but are not popularly used. For example, Johnson [38] used the economic anthropology approach for the poor peasants in Brazil.

CHAPTER III. THEORETICAL FRAMEWORK

Perfect and Imperfect Knowledge

Economic study may be viewed in two related areas. One deals with the situation of the perfect knowledge; this is the situation when all needed information is known ahead of time; therefore, the economic decision can be done perfectly right. For example, if a farmer knows exactly what the marginal value product of his fertilizer input MVP, and he knows the price of the fertilizer, then he can decide exactly what amount of fertilizer he should apply in his field in order to maximize his profit (by equating MVP to a price). In other words, one is able to obtain the optimum decision when he has the perfect information.

Another area of economics deals with the situation of the imperfect knowledge. There can be the case whereby all information needed exists, but the decision-maker is not aware of, or when the needed information does not exist at all. For example, a farmer can not know what the price of corn will be when sold, at the time he starts planting corn. Therefore, a farmer has to take the risk or uncertainty of corn prices while he begins his corn season.

Risk and Uncertainty

The situation under the imperfect knowledge will always be associated with the concepts of risk and uncertainty. These two concepts were first defined by F. H. Knight in 1919 [40]. He concluded that if the situation could be described by the objective probability it was called the uncertainty, if not it was called risk. In 1954, L. J. Savage [62] redefined those two concepts just the opposite of what Knight did. At present, the definitions by Savage are generally accepted by economists.

The concept of the probability has broadened; it now includes not only the objective probability but also the subjective probability, and one can see that almost every imperfect knowledge situation can be described by either subjective or objective probability or both, therefore, every situation may be viewed as risk. This may leave very few situations to be classified under the uncertainty. However, few people exercise care and observe how these two concepts are defined, therefore, both are generally used interchangeably.[1]

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[1]This study follows the general, i.e., it does not view the serious difference of these two concepts.

The Utility Function

The utility function is the key to this study. Most of the discussion about this function will be represented in this section.

A. Marshall was the first to introduce the concept of the utility [49]. His concept of the utility was obviously the cardinal concept [18, 28], and it had been used as introduced for a long period of time. Very recently, the utility has been thought of as the ordinal concept [37, 48, 55, 62]. This study also takes the utility concept as the ordinal utility.

The first form of the utility function is used for consumers. By this form, the utility U is a function of all goods Xi's. It explains that a consumer buys goods because he can consume the utility in the goods. The typical application of this form is to maximize the consumer's satisfaction by consuming quantities of goods Xi's, subject to his budget constraint, i.e., to maximize

$$U = U(Xi,\ i=1,2,\ldots,n)$$

subject to the given budget.

This type of function is known as the direct utility function. It has the great application into the modern economics, e.g., the estimation of the demand curve, the extension into the indirect utility function, the price and income policy theory, and so on.

The second form of the utility function which developed from the first one is applied to the producer. By this form, the utility U is a function of working income and leisure. It sees that the producer gets the satisfaction from the leisure and income from working. The typical problem of this kind is,

to maximize $U = U(Y,L)$

subject to the given amount of time which a producer has during a certain period of time. Where Y is the amount of the working income and L is the amount of leisure time or negative amount of working time.

The solution of the above problem is to allocate the working time for money Y, and the leisure time L in such a way that a producer may get the maximum utility. If the leisure is kept constant at $\bar{L}$, this type of the utility function may be written as,

$$U = U(Y) \quad \text{or} \quad U = U(Y,\bar{L})$$

or utility is a function of the income alone.

The above form of $U = U(Y)$ will be the standard form used in this entire study.

This ordinal utility is one of function which is very difficult to deal with. Because it is the ordinal number, i.e., it is relatively difficult to be estimated, it has no standard of measuring units of utility which enables comparison among individuals. However, the subsequent sections will discuss the way to overcome those problems and how the risk attitude of farmers can be derived from this kind of the ordinal utility function.

Construction of the Utility Index

The utility functions are constructed for each of the selected Iowa farmers, using the net farm income as the argument. The method used is known as the trial method of contract reference method [29].

By this method, and by this study, a farmer is told to imagine that he is doing his farming business with two possible outcomes of his net farm income. One is worth one and one half time his last year's farm income with probability P; another outcome is worth only one half of his last year's net farm income with probability of 1-P. Then, a farmer is requested to think further that he may or may not like those risky situations. If there is someone else who will take those risky situations for the farmer, and will let the farmer do his farming as usual, the farmer is requested to certify the least amount of sure dollars that a farmer will ask to sell out of those risky situations. An attempt is made to make it clear to a farmer that this least amount of sure dollars means the farmer does not see the difference whether he will take his own risky situations or let someone pay him the sure dollars in order to take over the risky situations.

Calculation of the utility index is not complicated. Assuming the number of the utility index is within the range of 0 and 100 (it can be within any range). The value of the one and one half times the net farm income, or X, is assigned to be 100, and the value of the half times the net farm income or Y is assigned to be zero. Then the utility index is calculated as,

$$U = 100(P) + o(1-P)$$

Note that the values of the lower and the higher index numbers are assigned depends upon the arbitrary range of the index number. For instance, the required range of the index number may be zero to 5,000 or 100 to 500, and so on. These ranges have no actual meaning; they are ordinal numbers.

For illustration, let the net farm income be $10,000. Therefore, the two outcomes are X = $15,000 and Y = $5,000 with the probability P and 1-P, respectively. Then, the values of P and 1-P are 90% and 10%, 80% and 20%, and so on up to 10% and 90%, and a farmer is asked to certify the least amount or the certainty equivalent accordingly.

The following table lists hypothetical values of X and Y with the associated probabilities, the dollars of the certainty equivalent, the utility index and the expected value of the risky situation. The expected value of the risky situation is calculated as $PX + (1-P)Y$; this expected value is given in order to show that the risk averse farmers always have the certainty equivalent dollars less than the expected value of the risky situation.

Table 1. Examples of values of the certainty equivalent, the utility index and others

P of X, X=$15,000	P of Y Y=$5,000	$ of certainty equivalent	The utility index	The expected value
100%	0%	15,000	100	15,000
90%	10%	14,000	90	14,000
80%	20%	13,000	80	13,000
70%	30%	10,500	70	12,000
60%	40%	10,000	60	11,000
50%	50%	9,000	50	10,000
40%	60%	8,000	40	9,000
30%	70%	7,000	30	8,000
20%	80%	6,500	20	7,000
10%	90%	6,000	10	6,000
0%	100%	5,000	0	5,000

The figures in this table are presented graphically in Figure 2.

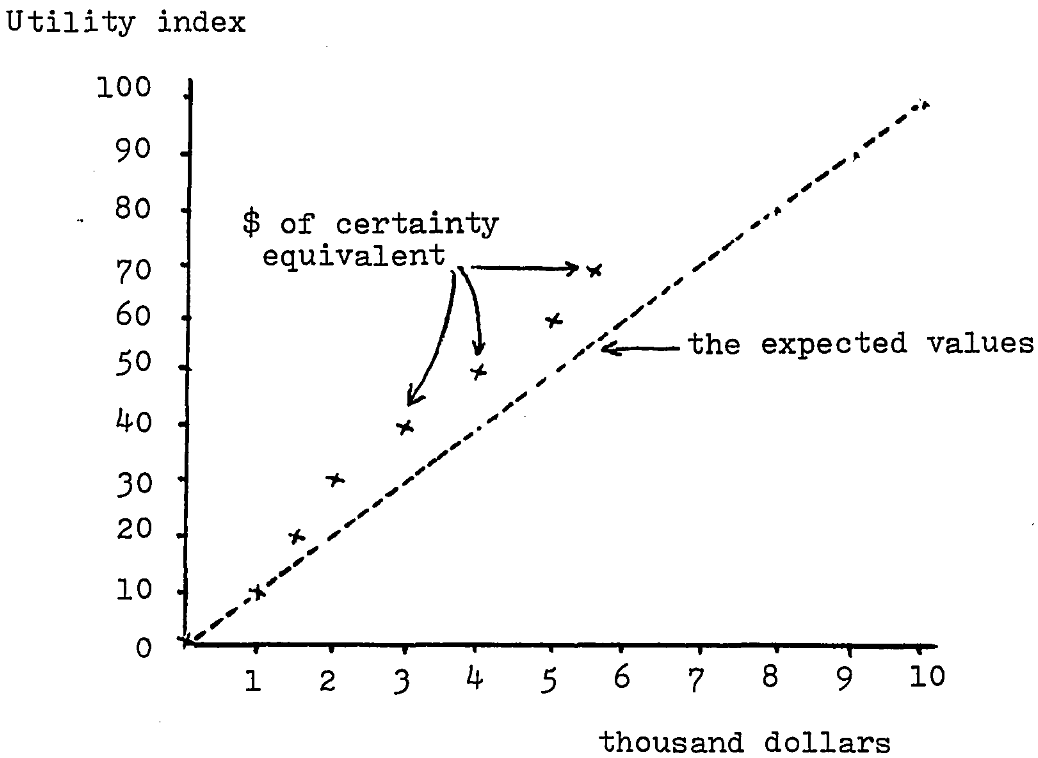

Figure 2. Showing the possible relationship of the utility index and the certainty equivalent values

Types of the Risk Attitude

In most cases, a farmer does not know exactly what his net farm income will be at planning stages of the seasonal operation. He has to use an estimation of his net income. The estimation can hardly be correct, but has a certain number of variability in the estimation itself. Generally, the farmer does not like this risk or this variability of the expected net farm income. However, some farmers may like the risk and some may not care about the risk at all.

People are broadly classified into three categories as to how they feel about risk: they are, risk averse, risk preference, and risk neutral. Each of these may be further subdivided as their risk attitude changes or their wealth changes.

(1) Risk averse: Risk averse people are those who get disutility from risk; therefore, they try to avoid risk. This is the case with most farmers.

(2) Risk neutral: These people ignore risk. In other words, they do not feel different in situations with or without risk.

(3) Risk preference: They are said to be in this group if they can get positive utility out of risk. These are people who are found in gambling places.

Some farmers subscribe to a mix of two or all three categories. For instance, the farmer may have a risk preference at the small amount of money and risk averse at the large amount of money.

Types of the risk attitude can be very illustrative when they are discussed with the help of either the utility function or the expected utility concept.

Types of Risk and the Expected Utility Function

The expected utility function may be derived from the known utility function.

Let the utility function be

$U = U(Y)$, or the utility U is a function of the income Y.

Apply Taylor's expansion around the mean $\bar{Y}$ and truncated after the second term assuming the rest is too small to be of any significance.[1]

$$E[U] = E[U(\bar{Y}) + (Y-\bar{Y})U'(\bar{Y}) + \frac{1}{2}(Y-\bar{Y})^2U''(\bar{Y})]$$

where U' and U" are the first and second derivatives of U

$$= U(\bar{Y}) + E(y-\bar{y})U'(\bar{Y}) + \frac{1}{2}E(Y-\bar{Y})^2U'(\bar{Y})$$

$$= U(\bar{Y}) + 0 + \frac{1}{2}\delta^2YU''(\bar{Y})$$

where

$\delta^2Y = E[Y-Y]^2$ or variance of Y,

---

[1]For example, the expansion of f(Y) around "a" is, $f(Y) = f(a) + (Y-a)f'(a) + \frac{1}{2!}(Y-a)^2f''(a) + \ldots$.

so, $E[U] = U(\bar{Y}) + \frac{1}{2}\,\delta^2 Y U''(\bar{Y})$

So, the expected utility is a function of the expected income and the variance of income [43]. Now, types of the risk attitude may be explained within the space of the expected income and the variance.

A farmer who is classified as the risk averse person prefers A to A'. Because both points show equal expected incomes but A' has a higher amount of the variability of income than A. This type of farmer will always select the

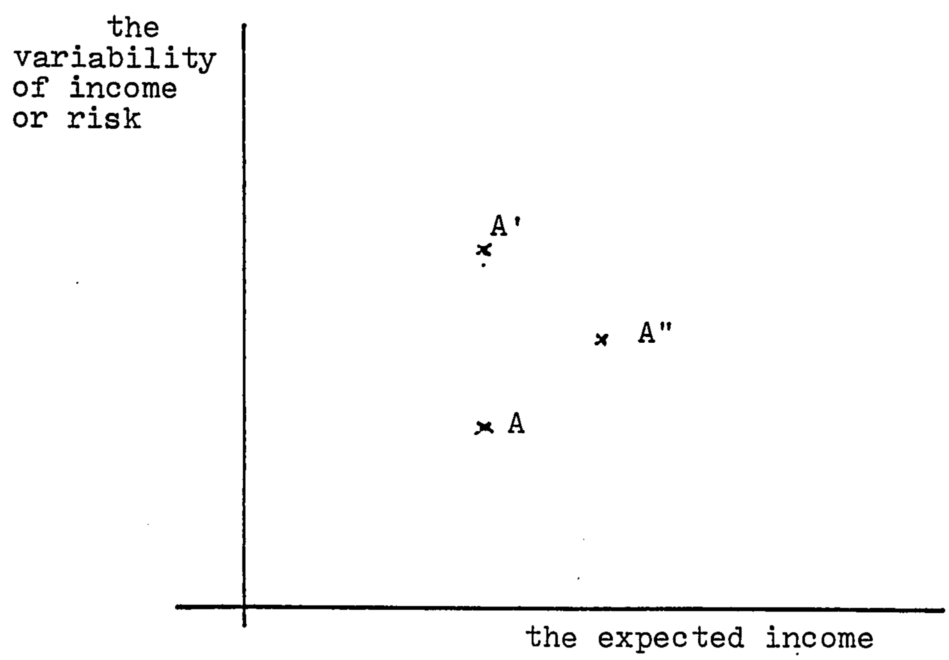

Figure 3. Types of risk by the space of the expected income and the variance

least amount of the variability of income if the expected income can be held constant.

The risk preferred farmer will select the opposite of the risk averse farmer. He selects A' instead of A, because he can have the additional utility by having the additional risk.

The risk neutral farmer does not see the difference between A and A' because he ignores the variability of income. In other words, he would have a preference for the highest of the expected income only.

Let A" be another point and particularly located as shown in the figure. Between choices of A and A" the risk neutral will select A", as A" has a higher amount of the expected income. The risk preference will select A" too as A" has a higher amount of both the expected income and the variability of income. But the risk averse farmer is very reluctant to select A or A". Because A" provides him more utility by having more of the expected income, at the same time it provides him less utility by adding the additional amount of the risk. He is not in a position to decide right away whether he prefers A to A", or vice versa.

Types of risk attitudes may be illustrated with the help of the direction of the E[U] curve. The E[U] curve shows the combination of the expected income and the variability of the income such that every point on the curve yields a farmer an equal amount of the expected utility.

The risk averse farmer has the E[U] curves that run from the southwest of the diagram to the northeast of the diagram or vice versa. This shows that he does not like the risk because the disutility of the additional risk has to be compensated by the utility of the additional expected income.

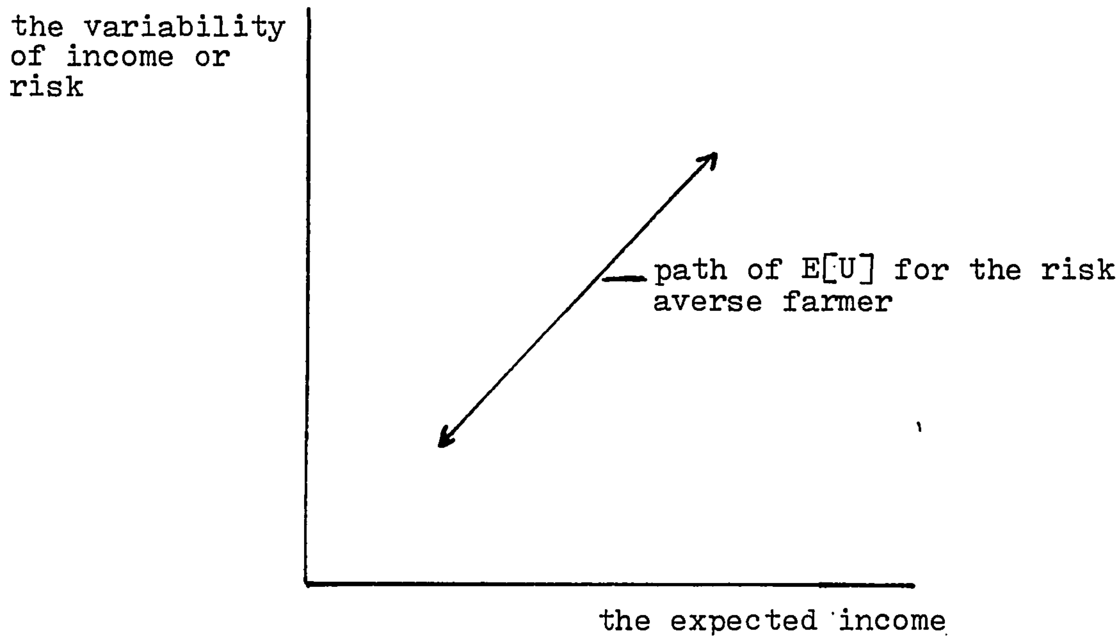

Figure 4. The E[U] direction of the risk averse farmer

The risk neutral farmer has the E[U] curve that runs vertically. It shows that a farmer does not consider the amount of risk at all. What he does care about is the amount of the expected income only.

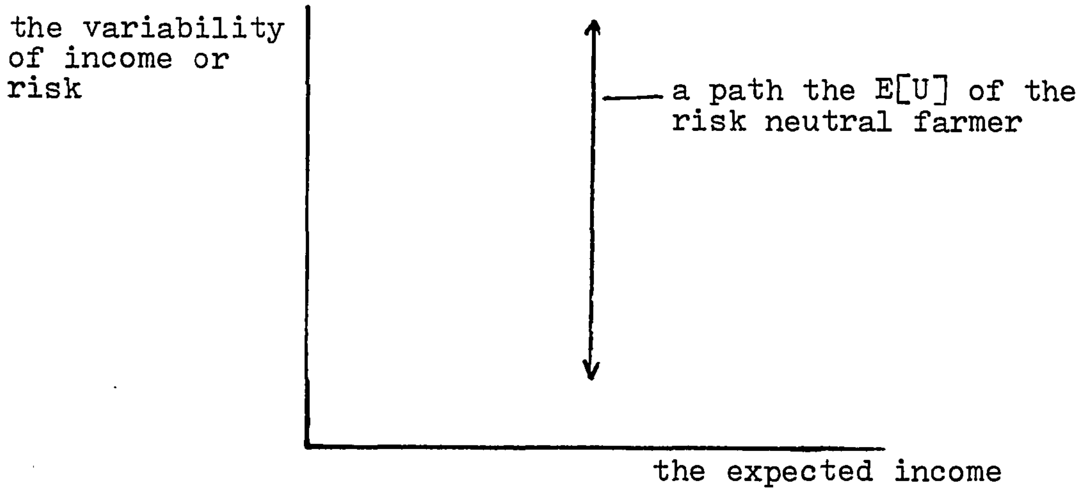

Figure 5. The E[U] direction of the risk neutral farmer

The risk preferred farmer has the E[U] curve running from the northwest to southeast. This shows that the less expected income can be compensated by the additional risk,

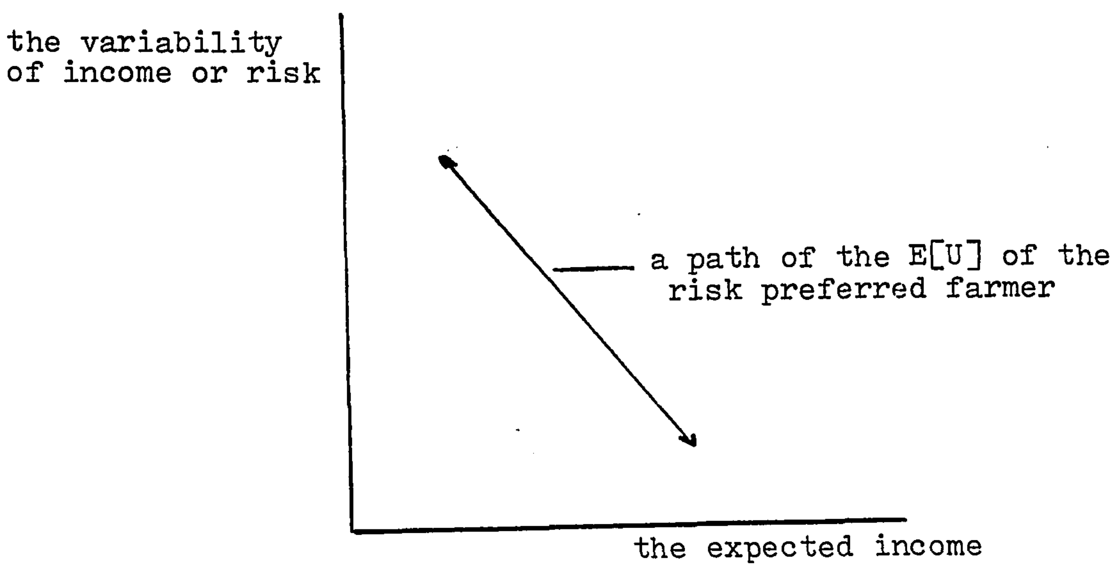

Figure 6. The E[U] direction of the risk preference farmer

or the more expected income is required if he has less risk.

Types of Risk and the Utility Function

The definition of risk averse may be made more meaningful and abstract. The risk averse people are defined as those people who prefer the expected value of the random variables rather than an opportunity of the random variables themselves [56].

The risk preferred people are opposite of the risk averse people, i.e., they prefer the opportunity of the random variables rather than the expected value of the random variables.

The risk neutral people do not see the difference between the opportunities of the random variables and the expected value of the random variables.

By these new definitions and the concept of the utility function, types of the risk attidude can be illustrated diagrammatically as shown in Figure 7.

Let Y_1 and Y_2 be two random variables with associated probabilities of P_1 and P_2, respectively.[1]

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[1]In this study, the two random variables are the two possible outcomes of the net farm incomes.

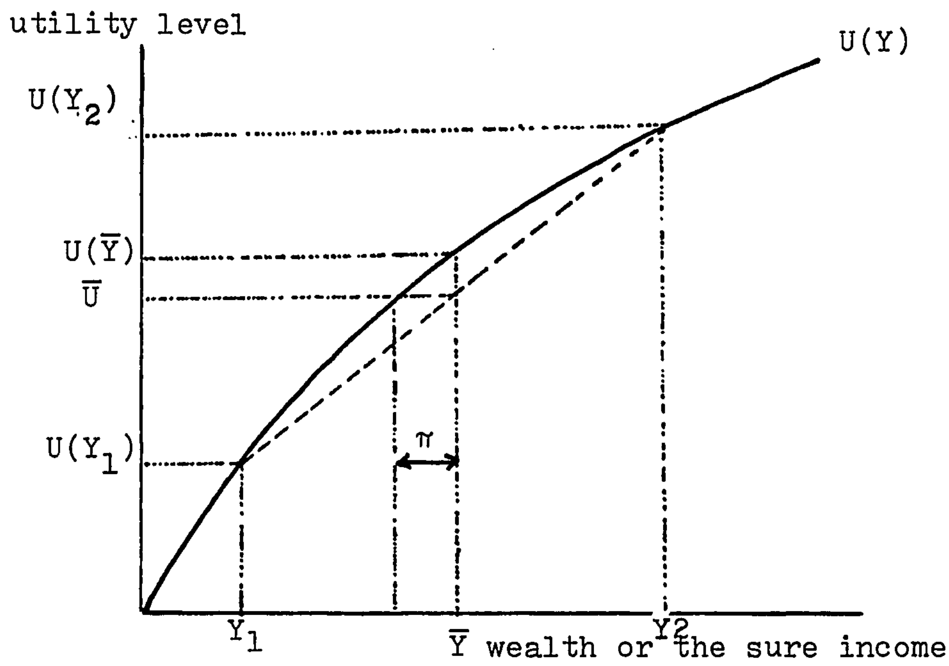


Figure 7. The curve of the utility function with the risk premium

Let $\bar{Y}$ be the expected value of Y_1 and Y_2, i.e.,

$$\bar{Y} = Y_1P_1 + Y_2P_2$$

and let utility levels of Y_1 and Y_2 be $U(Y_1)$ and $U(Y_2)$. Their expected utility $\bar{U}$ is,

$$\bar{U} = P_1U(Y_1) + P_2U(Y_2)$$

Figure 7 shows the utility curve of the risk averse farmer; it can be seen that the utility of the expected value of random variable, $U(\bar{Y})$ is higher than the expected utility derived from the opportunities of random variable,

$\bar{U}$. The difference is π where π is positive.

The value of π is sometimes called "the risk premium", it is the maximum value of wealth that a person will give up in order to avoid the risky situation.

For the case of the risk neutral, π is zero which means a person is not willing to pay the risk premium at all because the risk does not bother him. And the utility curve is the straight line.

For the case of the risk preference, π is negative or the utility curve is convex from below. This means that the person is willing to pay some money so that he can have the opportunity of taking risk on himself.

The sub-classification of the risk attitude is based upon how the risk attitude changes as he gets richer. The change of their risk attitudes can be seen from "the change of the risk premium over wealth." The risk premium over wealth means the maximum amount of money that he is willing to pay (to the insurance company, etc.) so that he can avoid the risk which may be attached to his additional dollar wealth. In mathematical language and notation, the risk premium over wealth is $\partial\pi/\partial Y$ or the first derivative of the risk premium with respect to his wealth. If he is risk averse with $\partial\pi/\partial Y = 0$, this means he is willing to pay the constant amount of the risk premium regardless of his increasing wealth, he is called the risk averse with constant risk averse. If he is risk averse with $\partial\pi/\partial Y < 0$, then he is willing to pay less amounts of risk premium as his wealth increases, and he is classified as risk averse with decreasing averse over wealth.

Similar classification and reasons go for the case of the risk preferred farmer too. If his wealth increases, and he is willing to pay more in order to have a chance of gambling, he is the risk preference type with increasing risk. If he is willing to pay less, he is the risk preference type with decreasing risk preference, and if he is willing to pay constantly, he is the risk preference type with constant risk preference.

The risk neutral type can not be sub-divided according to the increase of wealth because he is not willing to pay the risk premium at all.

Measurement of Risk Attitude

It was seen in the last section how important the value of the risk premium π for determination of risk attitude is. The following will show how the value of π may be obtained from the known utility function which has utility as a function of wealth or income.

Assuming the case of the risk averse, by its definition in the section "types of risk and the utility function". It may be written mathematically as,

$$U(\overline{Y}) > E[U(Y)]$$

then,

$$U(\overline{Y}-\pi) = E[U(Y)]$$

where π is a quantity that makes both sides equal.

Applying Taylor's expansion around mean $\overline{Y}$, and truncated after the second term by assuming the rest are too small.

$$U(\overline{Y}) + (\overline{Y}-\pi-\overline{Y})U'(\overline{Y}) \ldots = E[U(\overline{Y}) + (Y-\overline{Y})U'(\overline{Y})$$

$$+ \frac{1}{2}(Y-Y)^2U''(Y) \ldots]$$

$$U(\overline{Y})-\pi U'(\overline{Y}) = U(\overline{Y})(E[Y]-\overline{Y})U'(\overline{Y}) + \frac{1}{2}E(Y-\overline{Y})^2U''(\overline{Y})$$

$$= U(\overline{Y}) + 0 + \frac{1}{2}\delta^2 YU''(\overline{Y}),$$

$$\text{where } \delta^2 Y = E(Y-\overline{Y})^2$$

so,

$$\pi = -\frac{1}{2}\delta^2 Y \frac{U''(\overline{Y})}{U'(\overline{Y})}$$

The value of π is not easily calculated because a farmer may not know the value of $\delta^2 Y$. Some farmers may know the value of $\delta^2 Y$, subjectively, some may know this value objectively, but prefer to use the subjective value of $\delta^2 Y$. The value of $\delta^2 Y$ is a problem in this study also, because this study aims to estimate the value of π or the risk premium of the selected farmers.

It has been suggested by Pratt [58], that the risk attitude may be measured simply by,

$$\pi = -U''(\bar{Y})/U'(\bar{Y})$$

Where π is the number showing the risk attitude[1] of the selected Iowa farmers in this study.

There are also other ways to measure the risk attitudes; they have been discussed in the chapter Review of Literature.

It is interesting to note that the utility function is based on the ordinal number which has no meaning to be compared among farmers, but both π's are the cardinal numbers which can be used for comparison among farmers.

Risk Behaviors

Most of the studies that use the utility functions report that there is a percentage of farmers who are risk preference. For examples, the percentage of risk preference reported by Dillon and Scandizzo [16] was 21, by Francisco and Anderson [22], 5, Halter and Mason [29], as high as 33, by Binswanger [9], 19 percent, when the payoff was 0.50 real rupees, and 9 percent when the payoff was 5 real rupees, 2 percent when the pay off was 50 real rupees, and only 1

[1] π should not be confused with the π that stands for the risk premium. This study uses the notation π for two different meanings.

percent with 500 hypothetical rupees as the payoff.

Risk is logically known to create disutility, but why some people are risk preference. Some hypothetical answers will be attempted.

(1) When people buy the lottery with a change of winning one in a thousand chances, and with the payoff only $500 of what they pay for $1. They do not pay just for the sake of gambling but they pay in order to have "the opportunity of dreaming" of what they will do with the money they win. In other words, when they have to lose less and may get much, they become more risk preference. Under such situations, they do not count the expected value or the probability as the main concern.

(2) There are people who believe strongly in luck; perhaps they are always lucky. They do not believe in the objective probability. For example, if the objective probability of winning is 50%, they believe that their chances of winning is 70%, in other words they see that they are lucky people or they assign the subjective probability to be higher than the objective probability.

(3) Most farmers are well-aware of the agricultural risk and they are well-prepared for farming under

risk. For example, they may diversify their farming, use owned equity, use flexibility of enterprises and so on [35]. Therefore, their net farm income will not be very bad in a very bad year, but it may provide a good income in a very good year. Therefore, they feel it is worth taking a risk and behave as if they are risk preference, but in fact they are the well-planned risk averse farmers.

(4) There are people who are addicted to gambling. These people are not the objects of this study, or economics but the objects of the psychologist or the psychiatrist.

(5) Farmers who behave through the estimated utility function as risk preference but in fact they are not. This is due to the drawback of the utility function itself. This will be explained as follows.

From the section of the utility function, it has been derived that, $U = U(Y,\bar{L})$.

The first drawback is that this function is based on the no-risk or risk constant situation; risk does not really enter the function at all.

Secondly, the above function assumed the constant of the leisure $\bar{L}$, $U = U(Y,\bar{L})$ or $U = U(Y)$. This assumption does not really hold true because when farmers face risk they will change the $\bar{L}$. It can be observed that farmers may work harder or more working hours in the time of natural unfavorable conditions. In graphical framework (Figure 8), the U-curve may shift up or down. For example, points A, B and C are three points derived from the hypothetical situations of the questionnaires. The utility curve is estimated to be the risk preference but as a matter of fact those three points are the shifting of the three U-curves of the risk averse farmer.

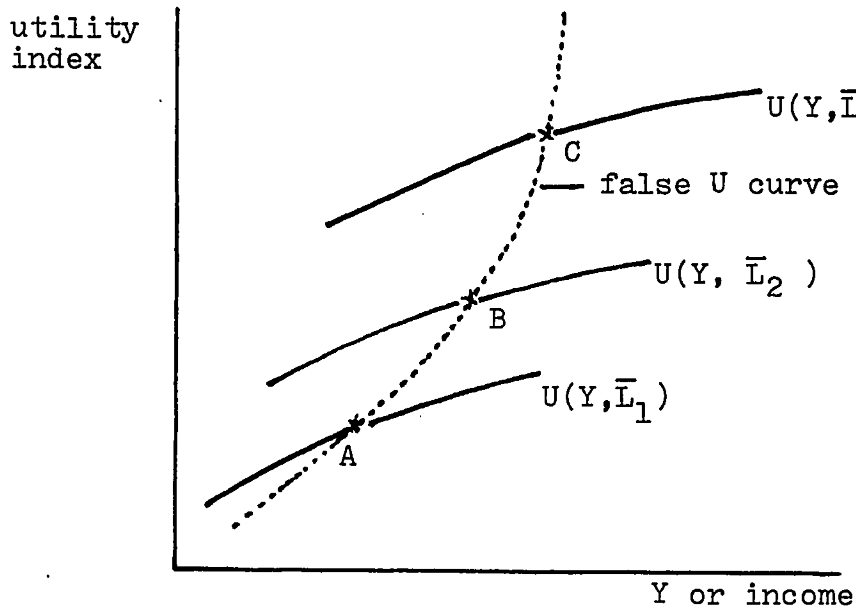


Figure 8. The shifting of the utility curves

In conclusion, farmers are always risk averse except for the small amount of loss due to high payoff, and except for farmers who believe that luck is always on their side. This conclusion leads this study to the assumption that all selected Iowa farmers are risk averse.

Reliability of Risk Attitudes

Risk attitudes are known to be inconsistent and unreliable. As a matter of fact, a man can never be consistent in his feelings, and the risk attitude is only a particular kind of human feeling. However, the human feeling, in general, can not be changed drastically over night. For instance, if a man loves the color pink today, he can not hate it the next day, but he may love the pink a little less. Similarly, the risk attitude of a man can not be drastically changed from one type of risky situation to another.

This study has constructed the risky situations that a farmer may choose. These situations are not exactly what farmers are really facing in actual farming (see section "Construction of the Utility Index", Chapter IV). Therefore, the result of this study may not be exactly what the farmers will do in their real farming operations.

However, economics is not an exact science; there are no exact answers. This study, also, does not give the exact results of the study, but it does tell what risk attitudes of farmers are all about.

Factors Affecting Risk Attitude

Economic theory suggests only two factors that affect the risk attitude, the level of the farm income, and the variance of the net farm income. These two suggested factors are well-integrated into the utility functions. Besides these two, there can be many more factors that affect risk attitude, but they go beyond economic theory. In this study, consideration will be given to some relevant factors as follows:

(1) Age of farmer: One may hypothesize that the younger farmer is less risk averse than the older one. Another may argue that the gamblers are not necessarily the young. This study will not hypothesize on this matter but find out what the actual situation is.

(2) Age of farmer's wife: A farmer is likely to assimilate the risk attitude of his wife into his own attitude. If the age of a farmer can affect her risk attitude, the age of his wife should also affect the risk attitude of the wife and then assimilate it into the attitude of the farmer.

(3) Years of schooling: Years of schooling will likely affect the attitudes of farmers, but it is not known whether it affects positively or negatively upon the risk averse. One may think that more schooling years makes a farmer understand the risky problems, i.e., he is less risk averse. One may argue the other way around too.

(4) Number of dependents: Having a greater number of dependents should limit the risk bearing ability of the farmer, i.e., he is expected to be more risk averse. However, the risk bearing ability and the risk attitude are not the same thing. He may have less risk bearing ability but his risk attitude can be much less averse.

(5) Years of experience in farming: This factor should work in the same manner as the case of "the years of schooling". One senior farmer may say that he has so much experience about risk, he knows how to handle it, i.e., he is less risk averse. Another farmer who has the same amount of experience says that he has undergone too many troubles with risk, and he does not wish to go through the same again, i.e., this farmer shows he is more risk averse.

(6) Total net assets: A larger amount of assets helps the farmer to handle a more risky agricultural enterprise. But a farmer who is capable of handling more risk is not necessarily the one who will actually follow through. Furthermore, the marginal utility of money is diminishing, i.e., a farmer with high net assets may not feel it is worth taking the relatively high risk.

(7) Acres per farm: More acres per farm implies higher net farm income, which should work the same way as the case of "the net asset he owns". However, they are not exactly alike; actual acres formed can be either owned or rented or both. In a bad year, the rented land can be a real liability to the farmer.

(8) Net farm income: The income is the flow concept. High income tends to encourage people to spend more, and the continuous period of high income will tend to establish a certain higher standard of living. People may be very conservative about risk taking when their income is close to his established standard of living. They may be more risk taking after he has become accustomed to the higher level of income. However, it is uncertain how high net farm income may affect the risk attitude of the farmer.

CHAPTER IV. METHODOLOGY

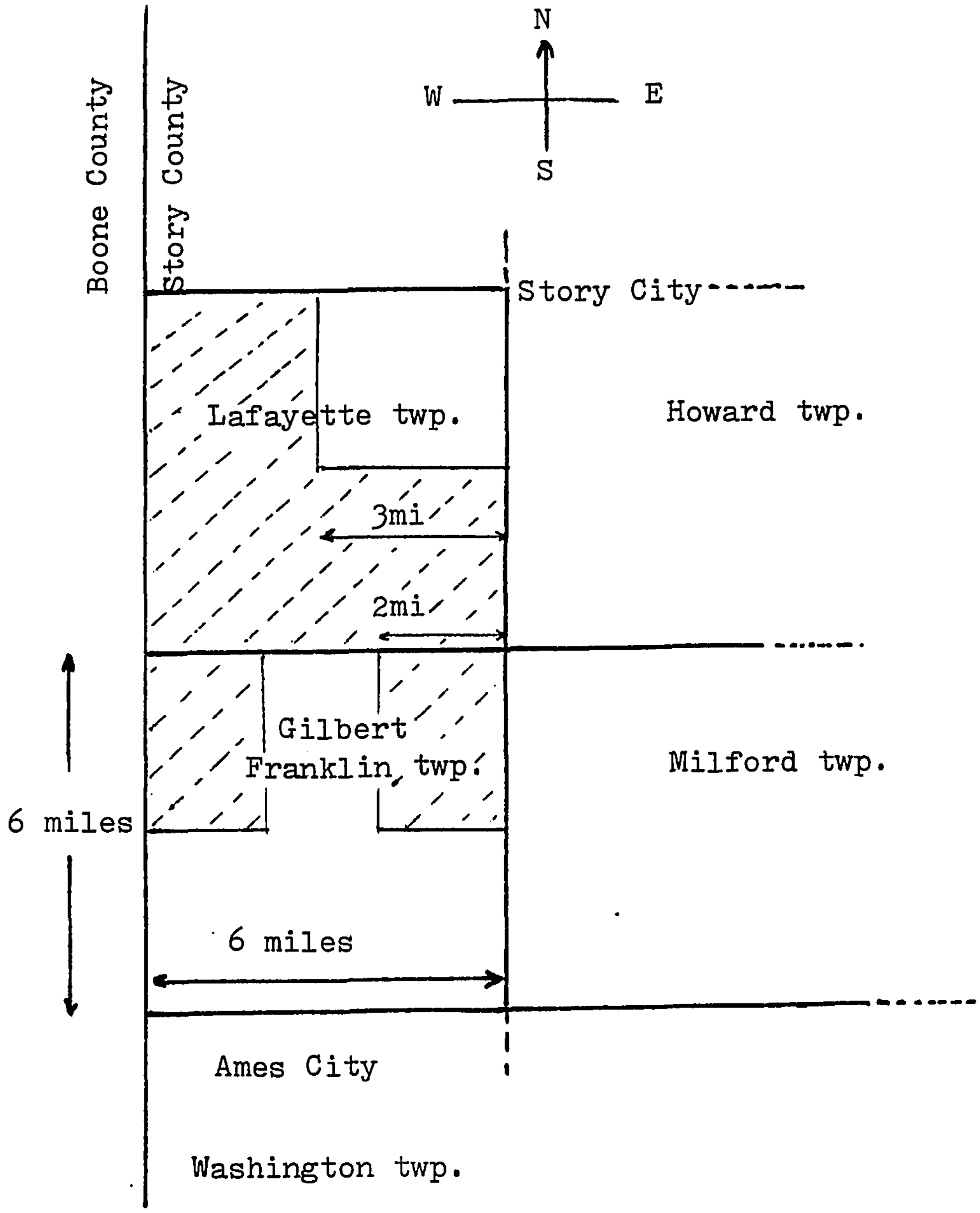
This study makes use of the primary data collected from farmers who live just north of Ames, Iowa. The main analytical tool is the Ordinary Least Squares Method.

Selection of Samples

The area situated to the north of Ames, Iowa was selected because it was close to where the researcher himself lived. There was no other prime reason for choosing this particular area over other areas near Ames. The area selected was the northern part of the Franklin Township and almost the entire area of Lafayette Township. Both townships are in Story County, Iowa, as shown in Figure 9.

Names of people were drawn randomly from the Story County, Iowa Rural Resident Directory, 1980 [17]. This was the most up to date directory available; it contains names of all rural people in the area regardless of whether they are farmers or not. The telephone was used to contact area residents, and to find out whether or not the people contacted qualified for the sample.

The people who qualified for the sample had to be farmers who earned at least half of their income from farming. They had to adhere to standard practices of agricultural enterprises which are generally practiced in the area. One farmer



indicating the selected area of the study.

Figure 9. The sampled area

contacted practiced farming by keeping and selling horses, therefore, he was not included in the sample because other farmers in the sampled area do not sell horses as part of the farming business. The common enterprises were field crops, pigs, and cattle.

Questionnaires

Survey schedules were used instead of the formal questionnaires. The survey schedule was a set of the informal questions with stated objectives. A formal questionnaire was not used because the number of people in the sample was relatively small and the researcher himself acted as field investigator.

There were two parts to the survey schedule. The first part dealt with the socio-economic background of the farmer. The summing-up results to the questions is located in the section "Socio-economic Background of the Selected Farmers", Chapter V. The second part dealt with decisions of farmers listed under hypothetical risky situations. The substance of this question given in the section "Construction of the Utility Index", Chapter IV.

Data Collection

The data were collected during the months of March and April, 1981, which was the off-growing season. This time of the year was selected so that farmers would have adequate time for being interviewed. Unfortunately, it was learned that most of the selected farmers were not at home during most of the day. The selected months were good for the farmers, but it was difficult to find them at their homes.

There were, altogether, 42 farmers whose data were collected successfully. Out of these, 6 indicated initially that they were risk preference (which was inconsistent with the assumption of this study). Attempts were made to find out why this was true. It was found that they misunderstood the questions, such as:

(1) They could plan their farming such that the outcome would not be as bad as the given hypothetical situation, and they could work harder if the outcome was bad.

(2) They used their own subjective probability on top of the objective probability given by the hypothetical risky situations given in the questionnaire.

They were made to understand that they could not use any technique or other probability besides the given one. It was explained to them why the risk was not good and why less risk was good. It was explained carefully because the field investigator wanted to avoid using any influence or show any personal bias to the farmers.

Lastly, five out of six changed their minds and indicated the preference of the sure thing over the risky one. Only one farmer stood firm as being a risk preference farmer. He was questioned further to see if he enjoyed taking a gamble; the answer was negative. His attitude was hard to understand because he was a risk preference farmer but did not like the gamble. He could be used as a special case to show that the risk attitude of people may drastically change from one type of risky business to another. However, this study was not framed to make a deep investigation into any one particular farmer; therefore, he was dropped from the analysis. So, 41 farmers remained for the analytical part of this study and all of them were risk averse.

Mathematical Form of the Utility Function

There are many mathematical forms that may fit the data of the hypothetical table in Chapter III of "Construction of the Utility Function", but, it is necessary to select the mathematical form that not only fits the data but also is consistent with the assumption about the risk attitude of the farmers also.

Following are the assumptions required for the utility function in this study.

(1) Utility is derived from wealth only. This implies that if there is wealth, there must be utility, and there is no utility without wealth. This also implies that the utility curve should pass through the origin of the diagram.[1]

(2) Wealth or money is not directly consumed by the farmers, it is used as a medium of exchange or the store of value; therefore, farmers can not be satiated. Farmers always find utility in having more wealth no matter how much they have. This implies that the utility curve never bends down toward the OX axis, regardless of how long the OX-asis may go.

(3) Money is used as a medium of exchange for goods, therefore, it has certain characteristics like any other goods. Thus, the marginal utility of money to the farmers is diminishing. This implies that the second derivative of the utility function with respect to wealth is negative or $U''(Y) < 0$.

(4) Farmers are assumed by this study to be the risk averse type. In other words, they always prefer the utility of the expected value of the random

[1]This requirement is not very strict because the utility index is ordinal and can be transformed monotonically.

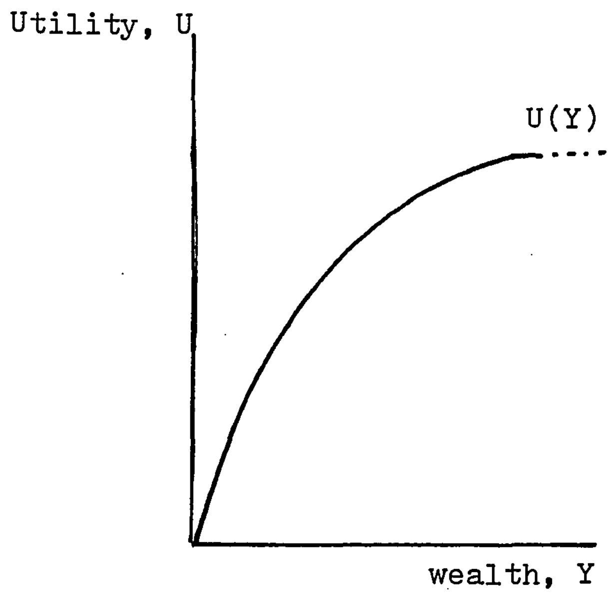


Figure 10. The right utility curve required by this study

variables rather than the utility of the random variables themselves. This means that it requires the risk premium π to be positive.

To meet this requirement, the utility curve must be concave from below or the first derivative of the utility function with respect to wealth must be positive. Stated mathematically, it requires $U'(Y) > 0$.

(5) Recall the section Types of Risk Attitudes and the Utility function, Chapter III; the person who is risk averse and with increasing risk over wealth has the risk premium π per dollar of wealth decreases

as the wealth Y increases. Using mathematical language, it says that the first derivative of the risk premium with respect to wealth is negative or $\partial\pi/\partial Y \quad 0$.

With all of the requirements and assumptions about the utility function in this study, two mathematical forms have been selected, e.g.,

(1) $U(Y) = Y^a$

(2) $U(Y) = a \log Y$.

The proof that these two selected forms of questions can fulfill all requirements and assumptions will be given as follows:

<u>Form 1</u>: $U(Y) = Y^a$ where $0 < a < 1$

where a is the estimated coefficient.

Differentiating, with respect to Y,

$$\frac{dU}{dY} = a\,Y^{a-1} \quad \text{where } (a-1) < 0$$

so,

$$\frac{dU}{dY} > 0 \tag{1.1}$$

$$\frac{d^2U}{dY^2} = a(a-1)Y^{(a-2)}$$

where $a(a-1) < 0$, so,

$$\frac{d^2U}{dY^2} < 0 \tag{1.2}$$

From the section Measurement of Risk Attitude,

$$\pi = -\frac{1}{2}\,\delta^2 Y\,\frac{U''(\bar{Y})}{U'(\bar{Y})}$$

does some substitutions from (1.1) and (1.2). Therefore,

$$\pi = -\frac{1}{2}\,\delta^2 Y\,\frac{a(a-1)Y^{a-2}}{aY^{a-1}}$$

$$= -\frac{1}{2}\,\delta^2 Y(a-1)Y^{-1}, \quad \text{note } (a-1) < 0, \text{ i.e., } \pi > 0 \qquad (1.3)$$

Differentiating π with respect to Y,

$$\frac{d\pi}{dY} = -\frac{1}{2}\,\delta^2 Y(a-1)(-1)Y^{-2}, \text{ note } -\tfrac{1}{2}(a-1)(-1) < 0, \text{ so}$$

$$\frac{d\pi}{dY} < 0 \qquad (1.4)$$

From the findings of (1.1), (1.2), (1.3) and (1.4), it is confirmed that the form $U(Y) = Y^a$ is satisfactory.

<u>Form 2</u>: $U(Y) = a \log Y$ where $a > 0$

Differentiating U with respect to Y,

$$\frac{dU}{dY} = aY^{-1}$$

so,

$$\frac{dU}{dY} > 0 \qquad (2.1)$$

The second order differentiation will be,.

$$\frac{d^2U}{dY^2} = a(-1)Y^{-2}, \quad \text{note } a(-1) < 0$$

So,

$$\frac{d^2U}{dY^2} < 0 \qquad (2.2)$$

From the section Measurement of Risk Attitude,

$$\pi = -\frac{1}{2}\,\delta^2 Y\,\frac{U''(\bar{Y})}{U'(\bar{Y})}$$

Substituting (2.1) and (2.2) into the above expression, i.e.,

$$\pi = -\frac{1}{2}\,\delta^2 Y\,\frac{a(-1)Y^{-2}}{aY^{-1}}$$

$$= \frac{1}{2}\,\delta^2 Y\; Y^{-1}$$

$$\pi > 0 \qquad (2.3)$$

Differentiating π with respect to Y, i.e.,

$$\frac{d\pi}{dY} = \frac{1}{2}\,\delta^2 Y(-1)Y^{-2}$$

$$\frac{d\pi}{dY} < 0 \qquad (2.4)$$

The finding in (2.1), (2.2), (2.3) and (2.4) suggests that the form of U(Y) = a log Y is acceptable to be used as the form of the utility function in this study.

Estimation by the Ordinary Least Square

The Ordinary Least Square (OLS) and the SAS programming package are used as the main statistical tool in this study. They are used for the estimation of the utility functions of each selected Iowa farmer. They are also used to investigate the effect of various factors upon the risk attitudes of the farmers.

The technique of the OLS is given in various texts of statistics and econometrics. This technique is very popularly used, regardless of it's restricted assumptions. This section will review only a few important assumptions in relation to the problem of this study [63].

Let the model be $Y = \hat{b}_1 + \hat{b}_2 X_2 + U_i$, where the Y and X_2 are a dependent variable and an independent variable, $\hat{b}_1$, $\hat{b}_2$ are estimated parameters and U_i is the random variable. The OLS estimators are said to be the Best Linear Unbiased Estimators (BLUE) if it can fulfill the following assumptions.

(1) $E[U_i] = 0$

(2) $V(U_i) = \delta$ for all i

(3) $COV(U_i, U_j) = 0$ where $i \neq j$

(4) X_i is fixed, i.e., it has no distribution.

There is no assurance in this study that all the above assumptions are satisfied. This implies that there is a chance that BLUE may not hold in this study.

In order to perform a statistical test of the estimated parameter $\hat{b}_j$, the additional assumption requires U_i to be independently normally distributed. This assumption is not assured in this study.

Another problem associated with the statistical technique of OLS is "the left out variable". This study defines that the utility depends upon only income, i.e., it is not complete. As a matter of fact, the utility may depend upon many other variables, e.g., leisure, types of agricultural enterprise, or the weather.

Some variables affecting risk attitudes may have been omitted in this study. This study specified only the relevant factors. As a result of the omitted variables, the statistical estimated parameters by OLS will be biased and the variance of the estimated parameters will not be efficient (minimum). These will lead to further testing of the statistical inference problem.

There are other problems in the study of the factors affecting risk attitude; it is the well-known multicollinearity. This is the situation when the independent variables are correlated, this will cause the variance of $\hat{b}_j$ to be unduly large, i.e., it may lead to the false conclusion that the independent variables do not affect the dependent variable.

Also, the estimated $\hat{b}_j$'s are no longer valid, because the effects of independent variables can not be separated.

This section stresses that there are drawbacks because OLS was used in this study. Therefore, one must be cautioned to interpret or use the results of this study.

Measurement of Dispersion: Skewness and Kurtosis

The concepts of skewness and kurtosis are very useful to study the shape of the probability distribution of any set of variables [63].

Skewness is defined as the third moment around the mean, divided by the third power of the standard deviation, i.e.,

$$SK = \{\Sigma(X_i-\overline{X})^3/n\}/\delta^3$$

where X_i is the value of the value of the variate i, $\overline{X}$ is a mean, n is number of variates, and δ is the standard deviation.

The value of SK is zero if the distribution is normally distributed because the positive values and negative values of $(X_i-\overline{X})^3$ are balanced, due to the symmetry of the distribution. If the distribution has a large, long tail to the right with the hump to the left, the value of SK is positive; the value of SK is negative if the large, long tail is to the left and the hump to the right. The shapes of the probability distribution with the positive and negative skewness are given in Figures 11 and 12.

Kurtosis is defined as the 4th moment around the mean, divided by the fourth power of the standard deviation, i.e.,

$$Ks = \{\Sigma X_i-\overline{X})^4/n\}/\delta^4$$

The value of Ks is always positive because of the fourth power of both the moment and the standard deviation. The value of Ks is 3 if the distribution is normally distributed. It will be Ks > 3 if the hump of the distribution is higher than that of the normal distribution. The flatter shape of distribution has the value of Ks < 3. The shapes of the distribution with K > 3, K = 3, and K < 3 are given in Figure 13 for comparison.

Chi-square Test for Normal Distribution

This study will need to test the distribution of certain risk attitude coefficients. The test is important because it will tell whether that distribution of risk attitude coefficients are normally distributed or not.

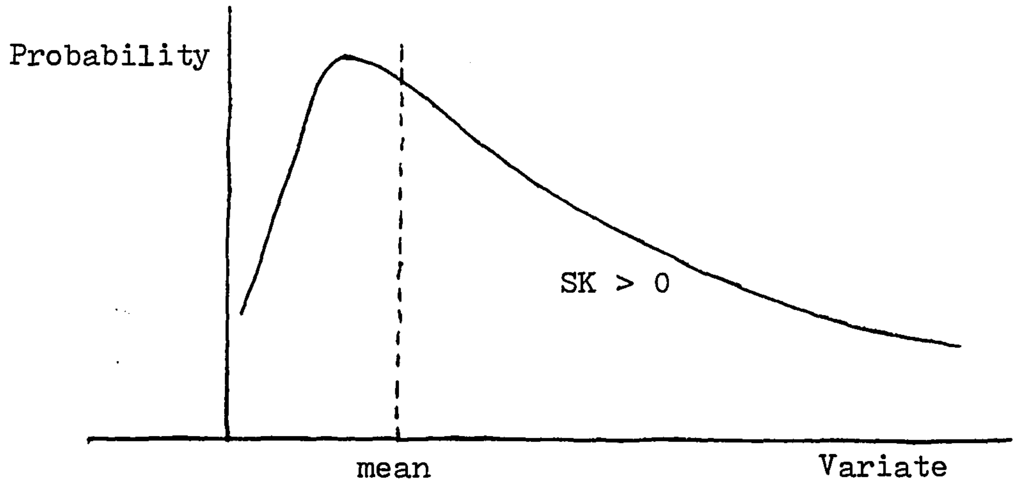


Figure 11. Distribution curve with positive skewness

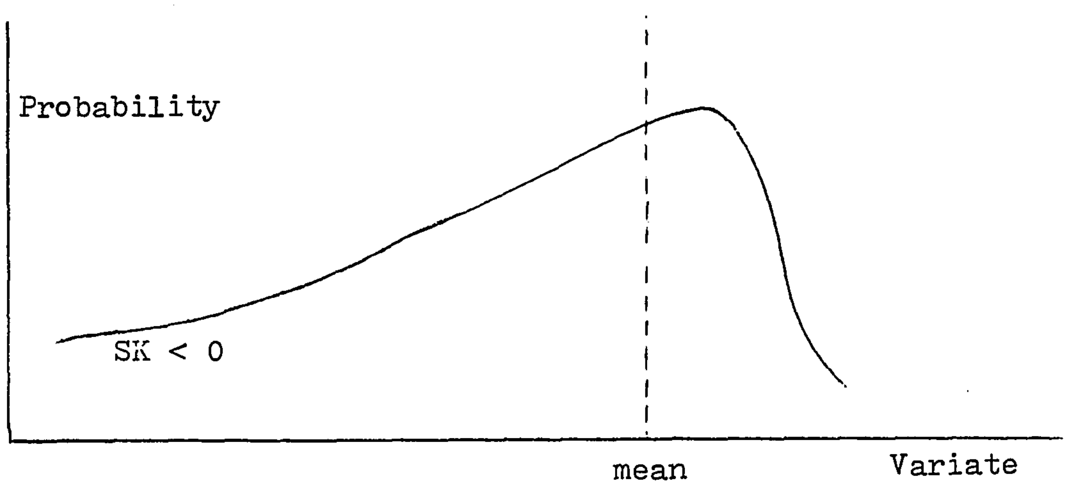


Figure 12. Distribution curve with negative skewness

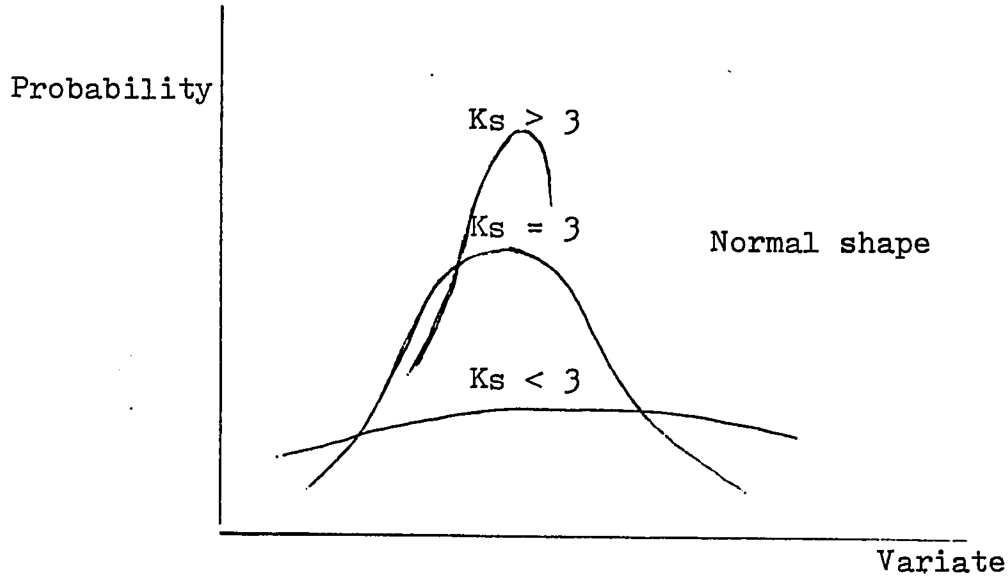


Figure 13. Distribution curves with different values of kurtosis coefficients

The chi-square test has a very broad application [63] but this section will only mention what is necessary for this research.

The risk attitude coefficients are arranged from the smallest to the largest value, then they are divided into P parts, each part shall contain at least 5 variates (chi-square test may not be recommended if there is a part which has less than 5 variates).

Then, the mean and variance of the population are estimated from the given risk attitude coefficients. If the mean and variance are known, and with the help of the normal distribution table, the expected frequencies of each part can be calculated.

The degrees of freedom in this case will be (P-3) because both mean and variance of the population are estimated.

More discussion pertaining to actual values of the risk attitudes are given in Chapter V when this test is actually performed.

CHAPTER V. RESULTS OF THE STUDY

The results of this study will be reported in the five following sections: (1) socio-economic background of selected farmers, (2) estimated utility functions, (3) estimated risk attitudes, (4) distribution of risk attitude, and last, (5) factors affecting the risk attitudes.

Socio-economic Background of Selected Farmers

This study aims to investigate neither detailed socio-economic conditions, nor the complicated farming business of the selected farmers. It merely aims to have minimal information about the farmers which will be sufficient to investigate the affect of these relevant backgrounds upon the risk attitudes. This information is given in summarized form in Table 2.

The average age of the farmers is 49.14 years, which is about 2 years older than the average wife; total years of schooling is about 1 year beyond high school graduation; and number of dependents, which includes the farmer and his wife, is 3.85. This number includes all persons whom the farmer supports either partially or totally.

The farmer's average years of experience in farming is 28.76 years, considering the average age is about 49 years, this implies that he began farming at approximately 21 years

Table 2. Socio-economic background of the selected farmers

Number	Socio-economic characteristics	Mean	Standard deviation
1	Age of farmer (years)	49.14	16.26
2	Age of farmer's wife (years)	47.21	15.89
3	Total years of schooling	13.12	4.29
4	Number of dependents	3.85	1.23
5	Years experience in farming	28.76	11.48
6	Total net assets (dollars)	356,489.48	29,706.83
7	Acres per farm	347.67	118.34
8	Net farm income of last year (dollars)	21,237.43	6,769.19

of age.

The farmer's total net assets averages $346,489.48, which includes both physical and nonphysical assets. This takes into consideration the amount of loans that he may have lent out or borrowed himself. All items, whether related to the farming business or personal possessions are taken into account. The value of physical assets are evaluated by the farmers themselves. It may be noted that this study does not break down this heading because this will be used as a factor that affects the risk attitude. when a farmer thinks of the risky situation or how much of a risk he will take, he does not break his total assets into various categories but rather, he takes into consideration his total assets.

Total acres per farm is averaged at 347.67 acres. This is the land that a farmer cultivates, whether he owns or he rents.

The net farm income of the last year is averaged at \$21,237.43. This amount excludes the amount of rent that a farmer may pay to a landlord (the concept of the net farm income is often used to include rent to a landlord).

Estimated Utility Functions

The estimation of the utility functions for each of the 41 selected farmers is done by the statistical ordinary least squares technique. Two functional forms of equations are used, i.e.,

$$U = Y^a \text{ or } \log Y = a \log Y$$

$$U = a \log Y$$

U stands for the utility index and Y for the sure income or the certainty equivalent certified by the farmers, and "a" stands for the parameter to be estimated.

The results of the estimation are given in Table 3. The first column of the table gives the farmer number for purposes of identification with which form of equation.

Table 3. Estimated coefficients of the utility functions of 41 selected Iowa farmers

Farmer number - form number	Estimate parameters, a's with standard errors in parentheses	R^2-value
1-2	0.398143 (0.098125)	0.9752
1-2	5.659996 (2.498021)	0.7358
2-1	0.435972 (0.075541)	0.9647
2-2	5.914763 (1.748012)	0.7344
3-1	0.381982 (0.071067)	0.982114
3-2	4.914728 (2.154725)	0.7468
4-1	0.417598 (0.121036)	0.9636
4-2	5.391250 (1.978176)	0.7946
5-1	0.374672 (0.081456)	0.9864
5-2	6.147678 (2.12089)	0.7538
6-1	0.425015 (0.198327)	0.9701
6-2	4.981814 (1.760275)	0.7718
7-1	0.394891 (0.078805)	0.9686
7-2	5.145853 (2.003210)	0.7108

Table 3 (Continued)

Farmer number - form number	Estimate parameters, a's with standard errors in parentheses	R^2-value
8-1	0.400812 (0.084846)	0.9586
8-2	5.530475 (1.883814)	0.7801
9-1	0.384276 (0.089214)	0.9664
9-2	5.861248 (1.173546)	0.7448
10-1	0.384819 (0.078718)	0.9636
10-2	5.97464 (1.414729)	0.7617
11-1	0.354159 (0.098276)	0.9705
11-2	5.630145 (1.782537)	0.7864
12-1	0.429925 (0.121745)	0.9775
12-2	6.280924 (2.000544)	0.8141
13-1	0.407424 (0.091984)	0.9690
13-2	5.532494 (1.953709)	0.7536
14-1	0.425995 (0.101089)	0.9784
14-2	6.224518 (2.988173)	0.8151

Table 3 (Continued)

Farmer number - form number	Estimate parameters, a's with standard errors in parentheses	R^2-value
15-1	0.420576 (0.121919)	0.9782
15-2	6.138597 (2.980843)	0.8132
16-1	0.442625 (0.071005)	0.9647
16-2	6.325361 (1.963895)	0.8146
17-1	0.425989 (0.069146)	0.9535
17-2	5.383972 (2.052623)	0.7258
18-1	0.423576 (0.129725)	0.9452
18-2	5.816351 (2.342127)	0.7436
19-1	0.405382 (0.130010)	0.9721
19-2	5.832850 (2.915127)	0.7936
20-1	0.462365 (0.091672)	0.9572
20-2	5.827210 (2.127628)	0.8018
21-1	0.437812 (0.131527)	0.9427
21-2	5.237651 (1.807051)	0.7964

Table 3 (Continued)

Farmer number - form number	Estimate parameters, a's with standard errors in parentheses	R^2-value
22-1	0.393421 (.144150)	0.9521
22-2	4.969883 (1.735009)	0.7551
23-1	0.427601 (0.085528)	0.9724
23-2	4.654513 (1.332192)	0.7892
24-1	0.467846 (0.122750)	0.9369
24-2	5.124111 (2.172171)	0.7356
25-1	0.380224 (0.087688)	0.9562
25-2	5.389124 (2.298321)	0.7334
26-1	0.385814 (0.160085)	0.9537
26-2	5.609597 (1.767827)	0.7701
27-1	0.396597 (0.161530)	0.9648
27-2	5.881215 (1.519436)	0.7821
28-1	0.421427 (0.183124)	0.9383
28-2	6.128867 (2.060085)	0.7389

Table 3 (Continued)

Farmer number - form number	Estimate parameters, a's with standard errors in parentheses	R^2-value
29-1	0.373802 (0.099415)	0.9548
29-2	5.770230 (1.942851)	0.7829
30-1	0.351273 (0.083192)	0.9508
30-2	4.837601 (2.065928)	0.7328
31-1	0.382858 (0.134215)	0.9621
31-2	5.265472 (2.042146)	0.7483
32-1	0.337183 (0.099815)	0.9701
32-2	5.528376 (1.965472)	0.7726
33-1	0.378301 (0.104159)	0.9547
33-2	4.996572 (2.102432)	0.7542
34-1	0.366547 (0.133472)	0.9643
34-2	4.783761 (1.984188)	0.7629
35-1	0.391259 (0.155558)	0.9523
35-2	4.988069 (2.127311)	0.7335
36-1	0.543613 (0.155246)	0.9508

Table 3 (Continued)

Farmer number - form number	Estimate parameters, a's with standard errors in parentheses	R^2-value
36-2	5.689973 (2.099415)	0.7290
3701	0.410792 (0.153817)	0.9525
37-2	5.837601 (2.065472)	0.7328
38-1	0.339528 (0.094384)	0.9512
38-2	4.831552 (2.001976)	0.7306
39-1	0.271437 (0.105467)	0.9617
39-2	5.434481 (2.312960)	0.7586
40-1	0.412552 (0.193129)	0.9654
40-2	4.853817 (2.145467)	0.7752
41-1	0.387241 (0.151154)	0.9653
41-2	5.719455 (2.293571)	0.7674

The second column shows the values of the estimated parameter "a" with the standard error of this estimator in the parentheses. The last column gives the value of R^2 or coefficient of variation.

From Table 3, it can be seen that the equation form (1) or the double log form gives very high R^2-value. The lowest R^2-value is still higher than 0.95. The values of the standard error (figures in parentheses) are also very low, all of the estimated parameters are significant above the 95% level of significance. The result of this form is highly satisfactory.

The semi-log form or form (2) is not a bad one, the lowest value of R^2 is above .71, the values of the standard errors are also low enough.

However, comparing form (1) and form (2) in every farmer number, one can find that form (1) is by far more superior to form (2) in both value of R^2 and value of the standard error of the estimated parameter. This leads to the conclusion that form (1) alone stands for the further analysis; because form (2) is not good enough to be an alternative for form (1) even if form (1) fails to do the analysis.

It should be noted that form (1) provides the calculated values of the elasticity of utility with respect to income directly.[1] This elasticity value is equal to the value of the estimated parameter. For example, if the farmer number 1 has his net farm income increased by 1%, he will get additional utility by 0.398143 percent (see farmer number 1, form number 1 in Table 3). This form, (1), is also said to provide constant elasticity. Because the value of elasticity is always constant, regardless of the level of net farm income he may receive.

Recall the implicit assumption of this study that all farmers are risk averse. The estimated utility function of form (1) (and also form (2)) is consistent with the assumption, as all estimated parameters of form (1) has value less than one. If it is one, it will be the case of the risk neutral, if it is more than one, it will indicate the risk-lover.

While estimating the utility function of form (1), it does not impose the estimation technique to have the estimate parameter to be less than one. If the estimated parameter is less than one, this implies two satisfactory consequences, first, the result of the estimation by the form (1) is consistent with the assumption, and/or secondly, the assumption about expected risk averse attitudes of selected Iowa farmers are correct, as proven by the

---

[1]If $U = Y^a$, then elasticity of U, with respect to Y, is $\frac{d \log U}{d \log Y} = a$.

results of the estimation by form (1).

Estimated Risk Attitude
Coefficients

As discussed earlier, there are many kinds of risk attitude coefficients. In this section, four kinds of risk attitude coefficients will be estimated from the double log form of the utility functions.

Recall the definition of the coefficients from Chapters II and III, that,

(1) The absolute risk averse, ARA by Pratt [58] is

$- U''(\bar{Y})/U'(\bar{Y})$

(2) The relative risk averse, RRA by Pratt is

$-[U''(\bar{Y})/U'(\bar{Y})]\bar{Y}$ or $RRA = ARA \cdot \bar{Y}$

(3) The risk premium, πP is $-\frac{1}{2}\delta^2 Y U''(\bar{Y})/U'(\bar{Y})$, or

$\pi P = \frac{1}{2}\delta^2 Y[-U''(\bar{Y})/U'(\bar{Y})]$

$= \frac{1}{2}\delta^2 Y \cdot ARA$

(4) The risk premium per one dollar of sure income, or, $\pi P/\$ = \pi P/\bar{Y}$.

For the form of the double log utility function, the above four definitions lead to the working formula for the practical calculation as follows:

(1) $RRA = (1-a)$

(2) $ARA = (1-a)/\bar{Y}$

(3) $\pi P = \frac{1}{2}(1-a)\delta^2 Y/\bar{Y}$

(4) $\pi P/\$ = \frac{1}{2}(1-a)\delta^2 Y/(\bar{Y})^2$

The values of these four kinds of coefficients are calculated by the above formula and given in Table 4. The value of $\bar{Y}$ and $\delta^2 Y$ are obtained from the hypothetical risky situation of 50%-50% chances of getting 3/2 times and 1/2 time of the last year net farm income. For example, the calculation for the farmer number 1 is from the situation that he may get \$18,000 with the probability of 0.5 and \$6,000, with the probability of 0.5, as his last year net farm income was \$12,000.

The hypothetical net farm income in Table 4 is not exactly the last year net farm income reported by farmers. The hypothetical one may be equal to, or slightly higher, than that reported. For example, if a farmer is reported to have \$11,500, the hypothetical one will be \$12,000. This will help the farmer to certify the certainty equivalent value more simply by thinking of the high outcome as \$18,000 and the low outcome as \$6,000 instead of \$17,250 and \$5,750.

The values of RRA in the table have been scaled up by 10^3 for being convenient, and by 10^7 for the case of ARA.

The last column is the risk premium in cents per one

Table 4. Values of RRA with 10^3 scaling up, the ARA with 10^7 scaling up, the risk premium dollars, and the cents of risk premium per one dollar of certainty

Farmer number	Hypothetical net farm income	RRA 10^3	ARA 10^7	Risk premium	Risk premium per one dollar of certainty
1	12,000	601.86	501.54	902.78	7.53
2	17,000	654.03	331.78	1,198.56	7.05
3	15,000	618.02	412.01	1,158.78	7.72
4	21,000	582.40	277.33	1,528.81	7.28
5	29,000	625.32	215.63	2,266.79	7.81
6	35,000	574.96	164.28	2,515.56	7.18
7	12,000	605.11	504.25	907.66	7.56
8	21,000	599.19	285.32	1,572.86	7.49
9	37,000	615.72	166.41	2,771.24	7.49
10	25,000	615.18	246.07	1,922.44	7.69
11	21,000	645.84	307.54	1,695.33	8.07
12	19,000	570.07	300.04	1,353.92	7.12
13	27,000	592.58	219.47	1,999.95	7.40
14	16,000	574.00	358.75	1,148.01	7.17
15	19,000	420.58	211.36	998.86	5.25
16	31,000	557.38	179.79	2,159.83	6.97
17	17,000	574.01	337.65	1,219.77	7.17
18	19,000	576.42	303.38	1,368.99	7.21
19	22,000	594.62	270.28	1,635.20	7.43
20	18,000	537.63	298.68	1,209.69	6.72
21	18,000	562.18	312.32	1,264.90	7.02
22	40,000	606.57	151.64	3,032.89	7.58
23	21,000	572.39	272.57	1,502.52	7.15
24	12,000	532.15	443.46	798.23	6.65
25	24,000	619.77	258.24	1,859.32	7.74
26	25,000	514.18	245.67	1,919.33	7.67
27	17,000	603.40	354.94	1,282.23	7.54
28	25,000	578.57	231.42	1,808.04	7.23
29	26,000	626.19	240.84	2,035.14	7.82
30	16,000	648.72	405.45	1,297.45	8.11

Table 4 (Continued)

Farmer number	Hypothetical net farm income	RRA 10^3	ARA 10^7	Risk premium	Risk premium per one dollar of certainty
31	14,000	617.41	440.81	1,079.99	7.74
32	22,000	662.81	199.69	1,822.47	8.28
33	26,000	621.69	239.12	2,020.52	7.77
34	20,000	633.45	316.72	1,583.63	7.91
35	18,000	608.74	338.13	1,369.66	7.61
36	24,000	456.38	190.16	1,369.14	5.70
37	27,000	589.20	218.22	1,988.55	7.36
38	21,000	660.47	314.51	1,733.74	8.25
39	16,000	728.56	455.35	1,457.12	9.10
40	32,000	587.44	183.57	2,349.79	7.34
41	14,000	612.76	437.68	1,072.32	7.66
Min. value		420.58	151.64	798.23	5.25
Max. value		728.56	504.25	3,032.89	9.10
Mean		595.59	296.21	1,614.13	7.42
Standard deviation		51.29	94.79	514.38	.64
Coefficient of variation		8.61%	32.00%	31.87%	8.29%

dollar of the net farm income. It is calculated by having \$ risk premium divided by the hypothetical net farm income.

The Absolute Risk Averse

The absolute risk averse, ARA is absolute in the sense that it is free from monotonic transformation of the utility function because $U''(\bar{Y})$ has been divided by $U'(\bar{Y})$. Pratt [58] has put the minus sign in the front of $U''(\bar{Y})/U'(\bar{Y})$ because the risk averse people always have $U''(\bar{Y}) < 0$, i.e., $-U''(\bar{Y})/U'(\bar{Y})$ always gives the positive value for risk averse persons.

With the double log form of the utility function, $ARA = (1-a)/\bar{Y}$ so the ARA decreases as the expected net farm income increases. In other words, a farmer becomes less risk averse for the additional expected net farm income. evaluation of the last years net farm income in Table 4 shows that the farmer who is the most risk averse has ARA = 504.25 which is more than 3 times that of ARA of the least risk averse farmer. The mean of ARA for the 41 selected Iowa farmers is 296.21 with the standard deviation of 94.79. The coefficient of variation is 32.00%.

The Relative Risk Averse

The relative risk averse, RRA is relative in the sense that it has integrated the magnitude of the net farm income into the measurement. The RRA is simply the product of ARA and the net farm income. The purpose of multiplying the ARA by the net farm income is to represent the effect of the net farm income upon the risk behavior of a farmer. For example, consider two farmers, one has low expected net farm income and is less risk averse, and one has high net farm income and is more risk averse. These two may behave very much alike during a risky situation because the farmer who is less risk averse is limited by the low net farm income, and the one with a high net farm income is restricted by the more risk averse. This is the reason why both ARA and the net farm income should be mutually expressed in the risk attitude of the people or farmers.

The lowest RRA in the table is 420.58, which is about 60% of the highest RRA of 728.56. (It is more than three times the case of the ARA.) The coefficient of variation is very low at 8.61%, this should explain why farmers do not behave much different from each other, even their ARA varies greatly. The mean of RRA is 595.59 with relatively small standard deviation at 51.29.

The Risk Premium

The risk premium indicates the maximum amount that a farmer will pay in order to have sure dollars for the hypothetical net farm income instead of having a 50% chance of getting 1.5 times more and a 50% chance of getting 0.5 times this income. For example, farmer number 1, in Table 4, is willing to pay at the maximum, $902.78, in order to have a guaranteed $12,000 net farm income, instead of having $18,000 with 0.5 probability of $6,000, with also 0.5 probability.

The risk premium is, in some sense, superior to the ARA and RRA, because the risk premium gives meaningful information, directly. It tells exactly how much a farmer will pay in exchange for protection of his net farm income.

From Table 4 we see that the value of the risk premium varies from the minimum of $798.23 to $3,032.89, with the mean of $1,614.13 and a standard deviation of $514.38; the coefficient of variation is about 30% of the mean.

The value of the risk premium is affected by the value of variance $\delta^2 Y$ as well as the net farm income, $\overline{Y}$. If the relationship between the risk premium and $\delta^2 Y$ is put into a graph, the straight line curve will be obtained. The curve between the risk premium and the net farm income will be hyperbola.

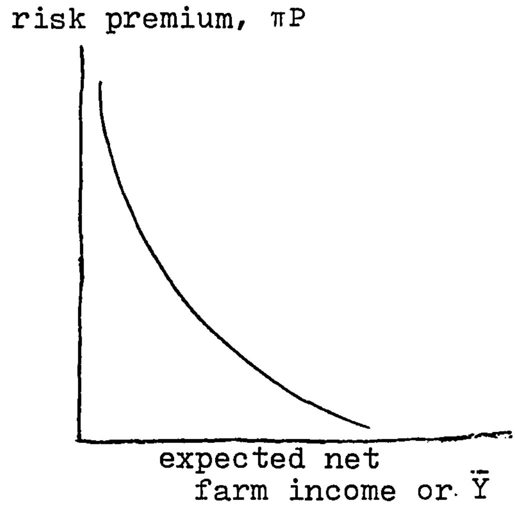


Figure 14. Relationship between the risk premium and the net expected income

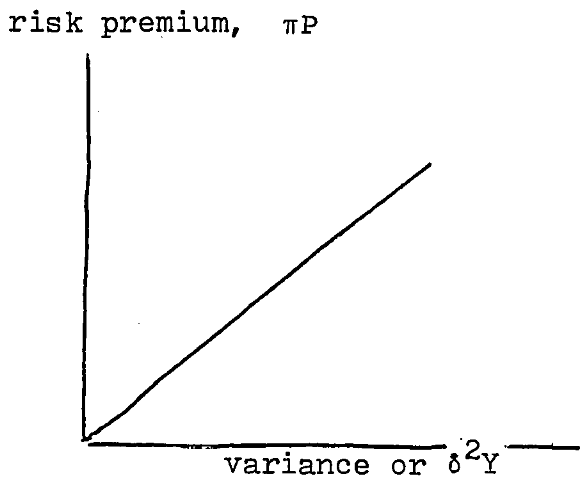


Figure 15. Relationship between the risk premium and the variance

Relationship between the Risk Premium, Variance Expected Income and the Probability

The risk premium, variance, and the net farm income are all affected simultaneously by the probability associated with the outcome. The interesting question is, if the probability changes, what changes can be expected on these three quantities?

Using a hypothetical situation, assume that a farmer changes the probability of the high and low net farm income from 90% and 10%, 80% and 20%, . . . to 10% and 90%. Then, the values of the risk premium, the expected net farm income and the variance are calculated (see Appendix B for the detailed calculations). The numerical results of the calculation are given in Table 5.

The unit Y and "a" in Table 5 stand for last years net farm income (or any constant number) and the estimated parameters of the utility function. The hypothetical high and low net farm incomes are 1.5Y and 0.5Y, respectively; actual values of the variance and the risk premium are scaled up by 100 for convenience.

The numbers in Table 6 are graphic. In the following graph, the unit of the expected net farm income is Y, the unit of the variance is Y^2 and the unit of the risk premium is $Y[(1/2)(1-a)]$.

Note that in order to see the relationship of these

Relationship between the Risk Premium, Variance
Expected Income and the Probability

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The numbers in Table 6 are graphic. In the following graph, the unit of the expected net farm income is Y, the unit of the variance is Y^2 and the unit of the risk premium is Y[(1/2)(1-a)].

Note that in order to see the relationship of these

Table 5. Numerical results of the expected net farm income, variance, and the risk premium by varying the probabilities of the high and low net farm incomes

Probability of the high and low net farm income	Expected net farm income, $\bar{Y}$ (unit = Y)	Variance of the expected net farm income, scaling up by 100 (unit = Y^2)	Risk premium, scaling up by 100 (unit = $Y(\frac{1}{2})(1-a)$)
0.90 and 0.10	1.4	9.0	12.60
0.80 and 0.20	1.3	16.0	20.80
0.70 and 0.30	1.2	21.0	25.20
0.60 and 0.40	1.1	24.2	26.62
0.50 and 0.50	1.0	25.0	25.00
0.40 and 0.60	0.9	24.2	21.78
0.30 and 0.70	0.8	21.0	16.90
0.20 and 0.80	0.7	16.0	11.20
0.10 and 0.90	0.6	9.0	5.40

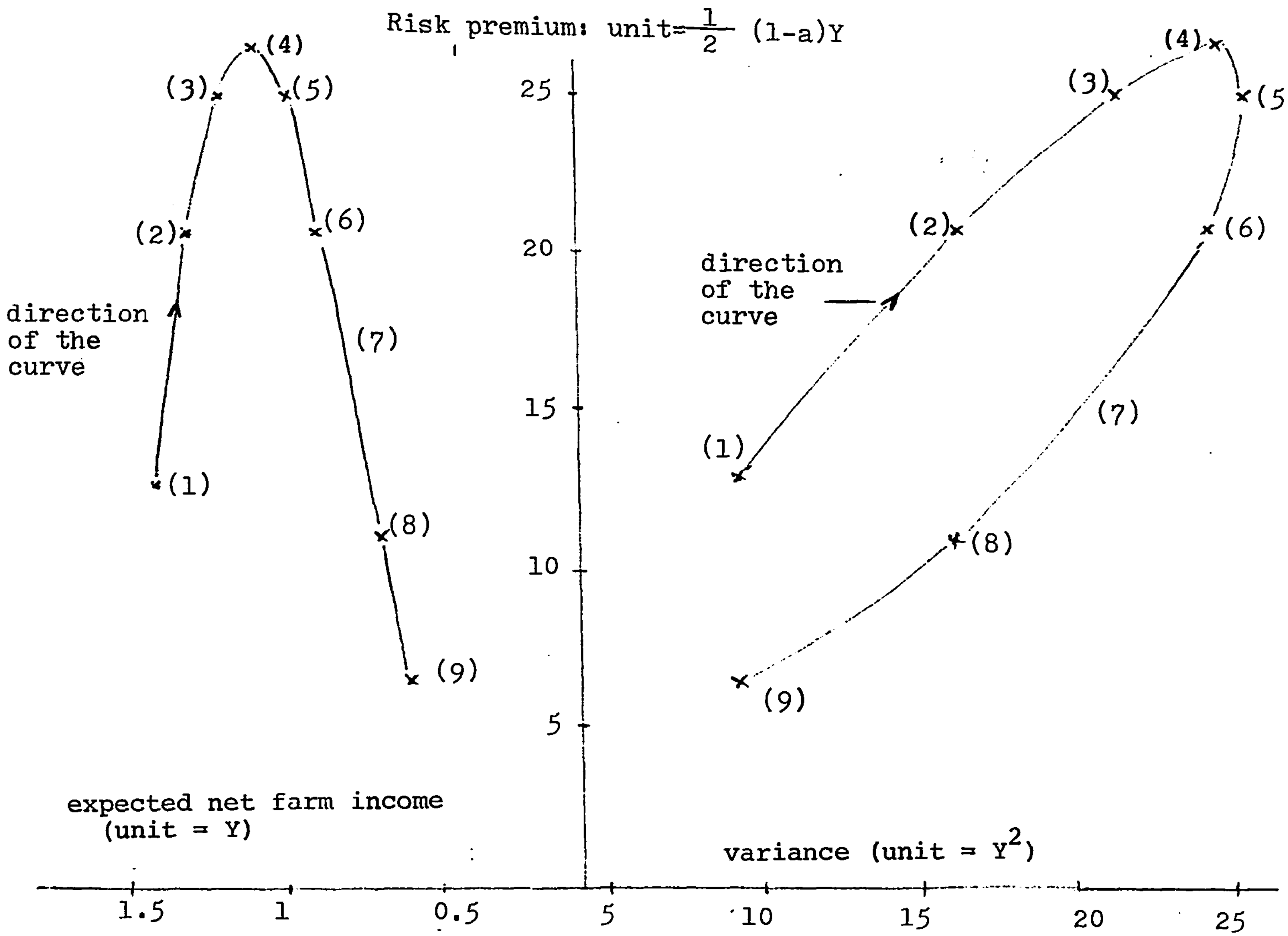

Figure 16. Effect of probability changes upon risk premium, variance, and expected net farm income

three quantities in the graph the value of Y and of "a" are not needed. This means that the graphical relationship of these three quantities always hold for all farmers who have the double log utility function regardless of the different values of Y's and a's of different farmers.

In this graph, points (1) represent the situation of 90% and 10% probabilities of the high and low net farm income . . . points (9) represent the situation of 10% and 90% probabilities of the high and low net farm income.

The curves show that the risk premium is highest at points (4), and the variance is highest at point (5) the number in the last 4 rows of Appendix B can prove these highest points).

This leads to the remarkable and theoretical conclusion that if the utility function takes the double log form, and if the probabilities of the two outcomes change, then:

(1) The highest risk premium, the highest variance, and the highest expected net farm income are not derived from the same situation of the probabilities;

(2) The highest risk premium is where the probabilities of the high and low outcomes are 60% and 40%;

(3) The highest variance is where the probabilities of the high and low outcomes are 50% and 50%;

(4) The highest risk premium is attained before the variance can reach the peak of the highest value;

(5) Both the risk premium and the variance increase while the expected income increases, but there are points where the variance and the risk premium turn backward while the expected income increases.

Marginal and Average Risk Premium with Respect to the Income

The average risk premium or the risk premium per one dollar of certainty is given in the last column of Table 4. The average risk premium given in this table is calculated on the certain condition of 50%-50% chances of having high and low net farm incomes. If these probabilities changed, the average risk premium will not be the same.

These average values appear to be centered around the mean of 7.42 cents per one dollar of the net farm income. They have a very low standard deviation at 0.64 cents and also very low coefficient of variation at 8.29%; maximum value is very large at 9.10 cents and minimum value is very low at 5.25 cents compared to the size of the standard deviation.

It is interesting to learn that most farmers are willing to pay the average risk premium at about 7.42 cents, regardless of their expected net farm income level or their socio-economic difference.

The marginal risk premium is the maximum amount that a farmer will pay in order to avoid the uncertainty of one additional dollar of his net farm income.

For the double log form of the utility function, the marginal risk premium is the same quantity with the average risk premium.

Distribution of Risk Attitude Coefficients

The simple graphical method showing the frequency distribution is the histogram, a simple concept of statistics dealing with skewness and kurtosis to show the shape of the probability distribution curves.

In order to construct the histogram in this section, risk attitude coefficients of each category are arranged from the smallest value to the largest value. The distance between the smallest value to the largest values is then

Table 6. Skewness and kurtosis coefficients of the risk attitude distributions

Risk attitude coefficient	Skewness coefficients	Kurtosis coefficients
RRA	-1.0546	4.1688
ARA	0.5798	-0.4324
Risk premium	0.7613	0.3611
Average risk premium	-1.0062	3.8500

divided into ten equal sections. The frequencies that fall into each section are counted and converted into percentage or probability.

The histogram of RRA, ARA, risk premium and the average risk premium are given in Figures 15, 16, 17 and 18, respectively. Coefficients of skewness and kurtosis of these four risk attitude coefficient distributions are given in Table 6.

Among the four categories of risk attitude coefficients, the average risk premium distribution has height closest to the height of the normal distribution, because it has the best kurtosis coefficient at 3.8500 where the one for normal distribution is 3. The ARA distribution is so flat that the kurtosis coefficient becomes negative at -0.4324.

Regarding the symmetry of the distribution, the RRA and the average risk premium distributions are shown to skew to the left, ARA and risk premium distribution are shown to skew to the right.

The Normality of the Relative Risk Averse Distribution

By the histograms in Figures 15-18, and by the coefficients of skewness and kurtosis, the RRA distribution is one of the most suspected to be normally distributed or it may not be significantly different from the normal

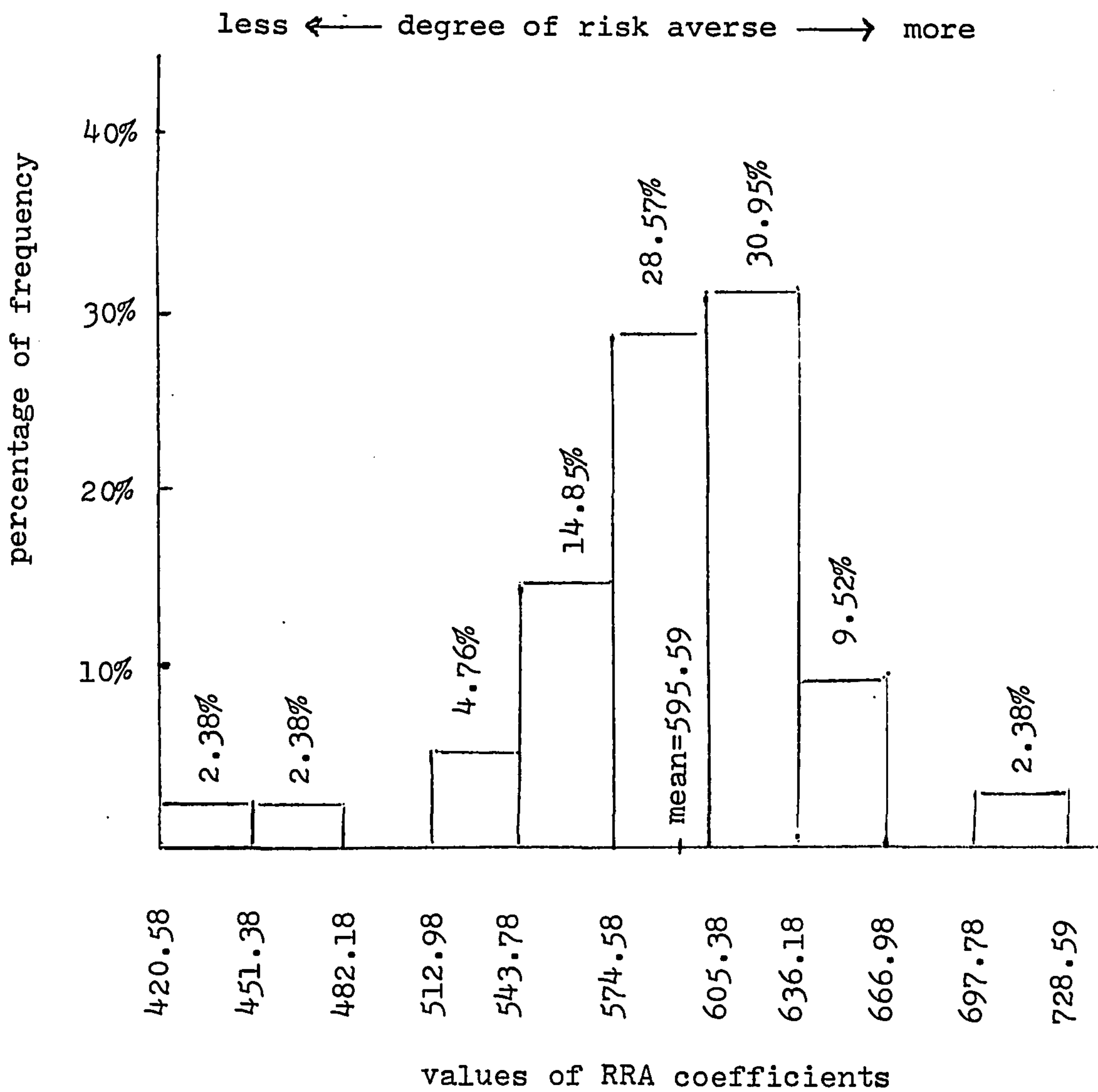

Figure 17. Percentage distribution of RRA coefficients

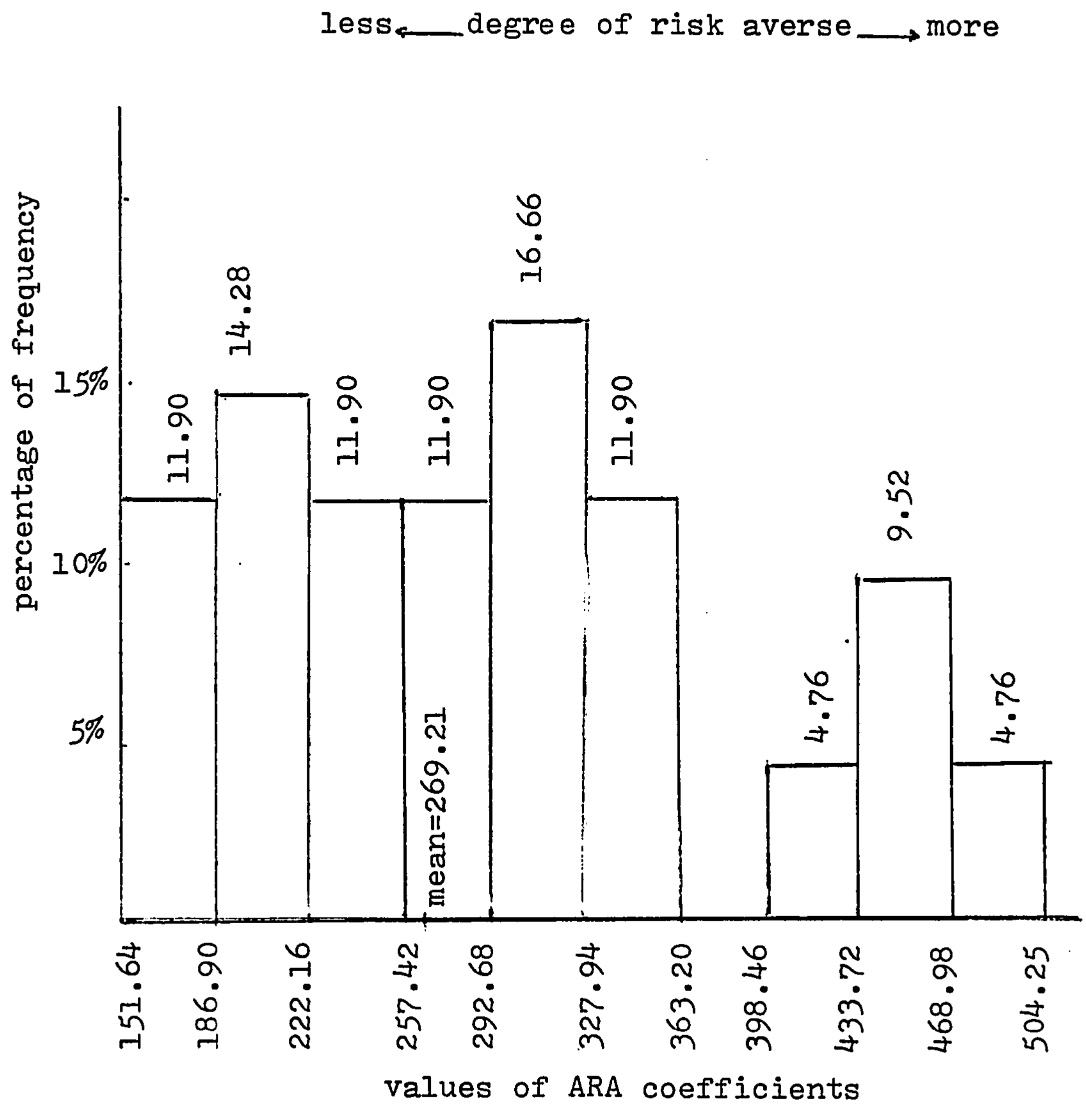

Figure 18. Percentage distribution of ARA coefficients

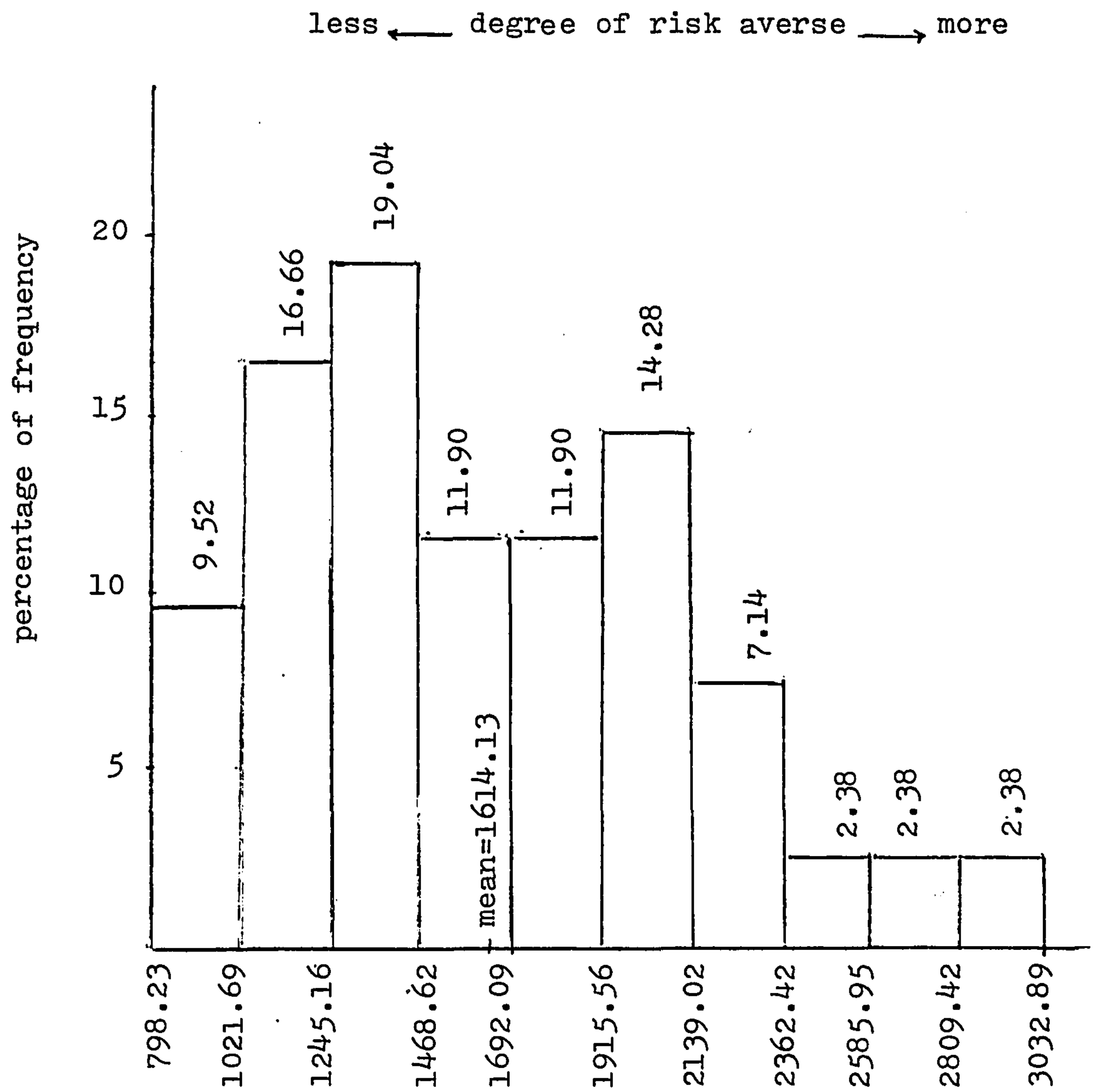

Figure 19. Percentage distribution of the risk premium.

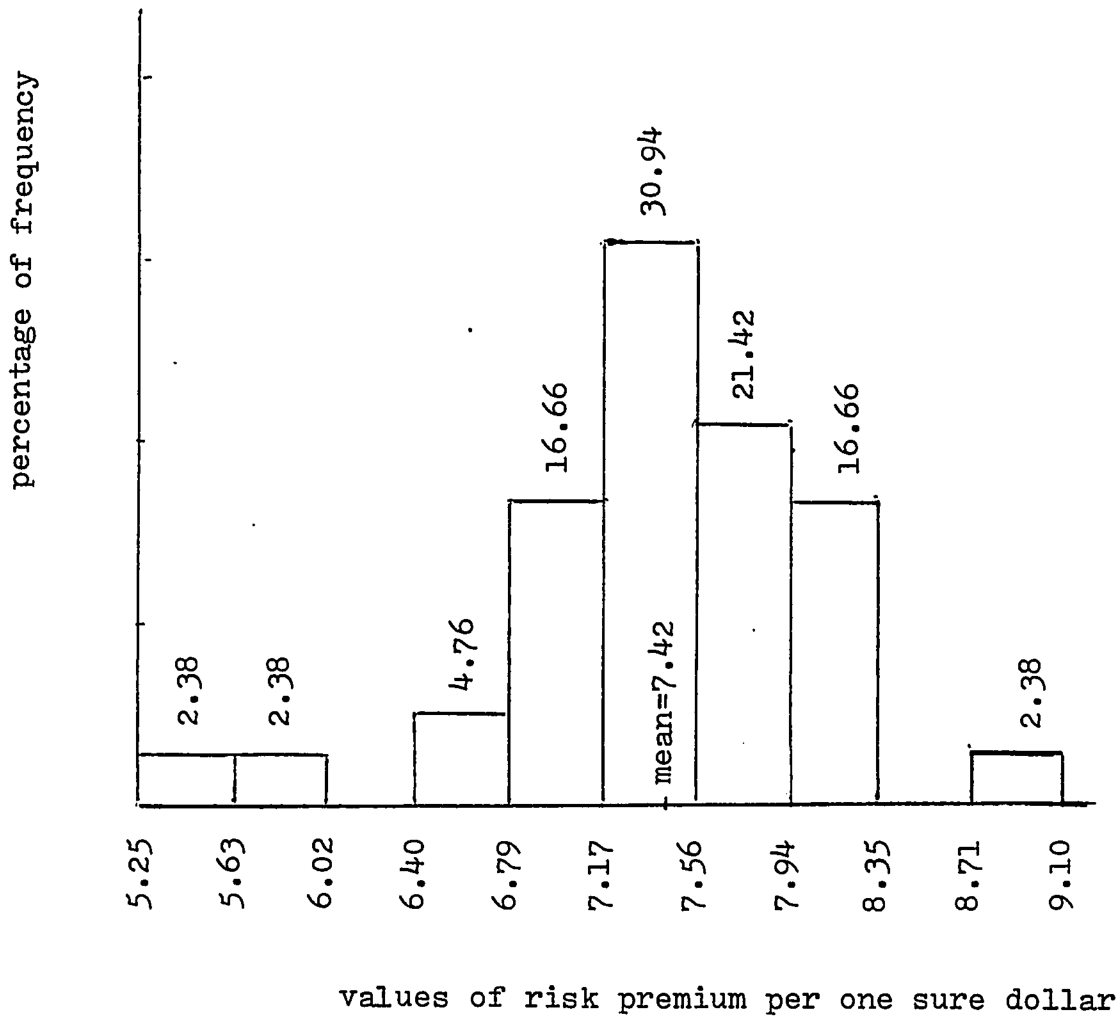

Figure 20. Percentage distribution of the risk premium per one sure dollar of the net farm income

distribution. This test can be performed by the simple x^2-test.

The normal test of RRA will be performed as follows:

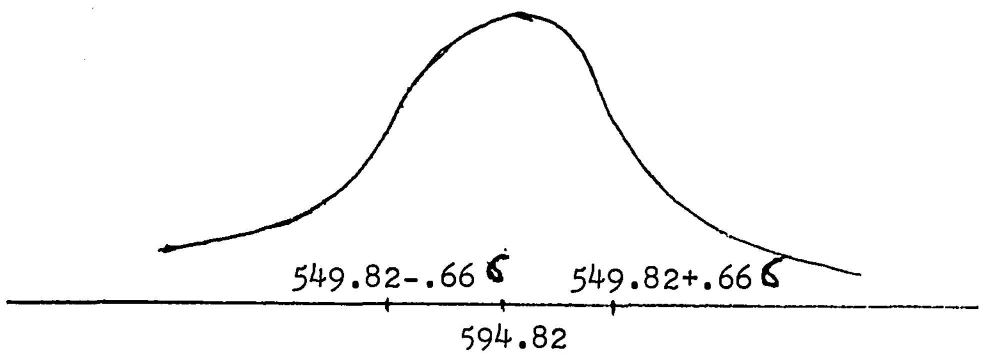

Figure 21. Division of RRA distribution (δ = variance)

The distribution is divided into 4 parts with the help of mean and variance as shown in the figure. And, with the help of the normal distribution table [63], the expected frequency of each part is obtained. The observed frequencies

Observed frequency	7	11	16	7
Expected frequency	9.11	11.39	11.39	9.11

are obtained by counting the set of RRA variables. The formula for this test is

$$X^2 = \sum_{1}^{4} \frac{(O-E)^2}{E}$$

where

O = an observed frequency

E = an expected frequency

The degrees of freedom in this case is only one because the mean and variance of population are estimated.

The value of the calculated X^2 turns out to be 2.8566 which is too large compared to the tabulated value. Therefore, it cannot be concluded that this distribution is like the normal distribution.

Factors Affecting Risk Attitudes

Various kinds of risk attitude coefficients have been estimated from the double log form of the utility function. As a matter of fact, all those coefficients depend upon only one value, "a", or the estimated parameter of the utility function.

The value "a" itself is assumed to be estimated constant for a farmer, but it varies from one farmer to the next. What makes "a" varied is the socio-economic background of the farmers. In other words, "a" is a function of all socio-economic variables, or,

$$a = \phi \text{ (socio-economic variables)}$$

or,

$$a = b_0 + b_1 \text{ (socio-economic variables).}$$

There are eight socio-economic characteristics listed in Chapter III which are considered to be important factors affecting the risk attitude. These eight variables are not really independent from each other, but the OLS which will be used for estimation requires them to be independent. Some of them may be dropped out.

(1) Age of farmer is not independent from the age of hiw wife. A farmer tends to marry a woman who is a few years younger than he, this is the social norm of this society. Therefore, the age of his wife variable should be dropped as the age of the farmer himself is more important. The simple correlation of these variables is as high as 0.9124.

(2) The age of a farmer and years of experience in farming are not theoretically independent. They start farming at the age of around 20 years old and continue doing so. The

older they are, the more experience they have. One should be dropped out, i.e., years of experience, which is seen to be the least affecting factor upon the risk attitude. The simple correlation of these is 0.8261.

(3) The acres per farm is correlated with the net farm income. Iowa farmers earn most of their farm income from the crop growing, i.e., more acres result in more net farm income. Acres per farm is dropped out. The simple correlation coefficient is 0.7612.

(4) The simple correlation coefficient between the total net asset he owns and the net farm income is also high as .7136. Most assets of the farmer are in the form of the investment in his farm, i.e., more net assets result in more net farm income.

(5) The age of a farmer and the net farm income is also correlated very highly and the simple correlation is 0.7215. As a farmer gets older, he has accumulated more wealth which is mainly invested in his farm resulting in the high net farm income. Both the age of the farmer and the net farm income are very important factors affecting risk attitude, unfortunately, they cannot be quantified in the same equation by the simple approach of OLS.

Now, there are only three variables which are really independent, they are the net farm income, the years of schooling and the number of dependent variables. These will be used for estimaticn.

Let $\bar{Y}$ be the net farm income

YSC be years of schooling

ND be number of dependents, and

"a" be the estimated parameter by the double log form of the utility function.

The result of the OLS estimation is,

$$a = \underset{(0.07520)}{0.4554} - \underset{(0.005716)}{0.1124}\,(YSC) + \underset{(0.010277)}{0.01486}\,(ND) - \underset{(0.001646)}{0.1610}\,\bar{Y}$$

$$R^2 = 0.46075$$

The figures in the parentheses are the standard errors of the estimated parameters.

The estimation shows the significant affect of the year of schooling, YSC very high significant affect of the net farm income, $\bar{Y}$ and relatively lower significant effect of the number of dependents. The value of R^2 seems to be high enough for the cross section data.

The higher years of schooling will decrease the value of "a" or will be more risk averse. In other words, the higher education makes farmers more risk averse.

The higher income will reduce the value of "a" or will be more risk averse. The rich farmers are more risk averse than the poor. Recall that an individual farmer becomes less risk averse as he gets richer $(ARA = (1-a)/\bar{Y})$. These two seem needed.

As farmers have a certain standard of living that they like to maintain without risk. As an individual farmer gets richer and gets above his desired level, he will be less risk averse because he has ensured himself the required income.

But in case of the cross section data all farmers are pooled together, every farmer has his own desired standard level of living. None in the group feel that they have the income above the desired level. Therefore, the explanation of how an individual feels when he gets richer cannot be applied to the case of the group of all farmers.

CHAPTER VI. SUMMARY

Risk attitudes of farmers are very important to the decision making under risk of farmers. There are many methods to study the risk attitude. This study used the method called the direct application of the utility function. This method involves the construction of the utility functions for selected farmers. Then, the risk attitude measurement coefficients are derived from the constructed utility functions. These measurement coefficients used are the absolute risk averse coefficient, the relative risk averse coefficient, and the risk premium.

This study includes data collection from 41 randomly selected farmers whose farms are located on the north of Iowa State University campus, Ames, Iowa. Two forms of the utility functions are used, they are the double log form and the semi-double log form. This utility function says that the utility is a function of only income. The estimation technique of the utility function is the ordinary least squares method. The result of the study of this estimation shows that the double log form is the only one accepted to be used in this study. This study has the hypothesis that selected farmers are all risk averse, and this hypothesis is confirmed by the result of this study.

The probability distribution of the estimated risk attitude coefficients are proved to be significantly different from the normal distribution. The proof done by the chi-square method. Attempt has been made to consider what factors may affect the risk attitude. Three variables; net farm income, years of schooling and the number of dependents, have been successfully tested to be factors affecting the risk attitude. The method of testing is again the ordinary squares method.

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The Iowa State University Committee on the Use of Human Subjects in Research reviewed this project and concluded that the rights and welfare of the human subjects were adequately protected, that risks were outweighed by the potential benefits and expected value of the knowledge sought, that confidentiality of data was assured and that informed consent was obtained by appropriate procedures.

APPENDIX A

The shape of the E[U] curves are generally drawn as concave from below in most textbooks [1]. This simply means that the risk averse without referring to what kind of risk averse. As a matter of fact, there is no relationship between the concave E[U] curve and the kind of risk averse. The concave E[U] curve is simply drawn from the following assumption.

Let $EU = Q(E,V)$

where

E is the expected income

V is the variability of income which is measured by variance.

The assumptions about derivatives are,

$Q_E > 0, \qquad Q_{EE} < 0$

$Q_V < 0, \qquad Q_{VV} > 0$

Q_{EV} or $Q_{VE} > 0$, and $dV/\partial E > 0$.

The proof of concavity of the E[U] curve can be done as below.

Taking the total differential of the expression and equating it to zero,

$$0 = dE[U] = \frac{\partial Q}{\partial E} \cdot dE + \frac{\partial Q}{\partial V} \cdot dV$$

or,

$$\frac{dV}{dE} = - \frac{Q_E}{Q_V} > 0$$

$$\frac{d}{dE}\left(\frac{dV}{dE}\right) = -\left[\frac{Q_V(Q_{EE} + W_{EV}\ \partial V/\partial E) + Q_E(Q_{VE}+Q_{VV}\ \partial V/\partial E)}{[Q_V]^2}\right]$$

$$\frac{d}{dE}\left(\frac{dV}{dE}\right) < 0$$

Therefore, the E[U] curve is concave from below.

This concave E[U] curve has the advantage when it is used with the concept of the efficient frontier of the portfolio as it always gives the uncomplicated unique solution. However, this study does not aim to use the estimated utility function for this purpose, therefore, it will not pay any serious attention whether the estimated utility function has the concave E[U] curve or not.

APPENDIX B

Let $Y_H = 1.5Y$ be the high net farm income with the probability P_1, Y may be the net farm income of the last year or any constant number.

$Y_L = 0.5Y$ be the low net farm income with the probability P_2.

i.e., $P_1 + P_2 = 1$

$$\overline{Y} = P_1 Y_H + P_2 Y_L$$

$$\delta^2 Y = P_1 (Y_H - \overline{Y})^2 + P_2 (Y_L - \overline{Y})^2$$

The numerical calculation is given in the following data.

P_1 of Y_H	P_2 of Y_L	$\overline{Y}$	$P_1(Y_H-\overline{Y})^2$	$P_2(Y_L-\overline{Y})^2$	$\delta^2 Y$	$(\delta^2 Y)\overline{Y}$
0.9	0.1	1.4Y	$0.009Y^2$	$0.081Y^2$	$0.090Y^2$	0.1260Y
0.8	0.2	1.3Y	$0.032Y^2$	$0.128Y^2$	$0.160Y^2$	0.2080Y
0.7	0.3	1.2Y	$0.063Y^2$	$0.147Y^2$	$0.210Y^2$	0.2520Y
0.6	0.4	1.1Y	$0.096Y^2$	$0.146Y^2$	$0.242Y^2$	0.2662Y
0.5	0.5	1.0Y	0.1254^2	$0.125Y^2$	$0.2504Y^2$	0.2500Y
0.4	0.6	0.9Y	$0.146Y^2$	$0.096Y^2$	$0.242Y^2$	0.2178Y
0.3	0.7	0.8Y	$0.147Y^2$	$0.063Y^2$	$0.210Y^2$	0.1690Y
0.2	0.8	0.7Y	$0.128Y^2$	$0.032Y^2$	$0.160Y^2$	0.1120Y
0.1	0.9	0.6Y	$0.081Y^2$	$0.009Y^2$	$0.090Y^2$	0.0540Y
0.61	0.39	1.11Y				0.2641Y
0.59	0.41	1.09Y				0.2637
0.51	0.49	1.01Y			$0.2499Y^2$	
0.49	0.51				$0.2499Y^2$	

The calculation of the first row may be used as an example.

$$\overline{Y} = 0.9(1.5Y) + 0.1(0.5Y)$$

$$\delta^2 Y = 0.9(1.5Y - 1.4Y)^2 + 0.1(0.5 - 1.4Y)^2 = 0.090Y^2$$

$$(\delta^2 Y)Y = (0.090Y^2)1.4Y = 0.12604$$